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Is occupational status a fundamental cause of site-specific cancer mortality inequalities in 2001-2011 among the Belgian population?

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Abstract

Objective: This study probes into site-specific cancer mortality inequalities by occupational status among Belgians, adjusted for other SEP indicators.

Design: This cohort study is based on record linkage between the Belgian censuses of 1991 and 2001 and register data on emigration and mortality for 01/10/2001-31/12/2011.

Setting: Belgium

Participants: The study population contains all Belgians within the economically active age (25-65 years) at the census of 1991.

Outcome measures: Both absolute and relative measures were calculated. First, age-standardized mortality rates (ASMR) have been calculated, directly standardized to the Belgian population. Secondly, mortality rate ratios were calculated using Poisson regression, adjusted for education, housing conditions, attained age, region and migrant background.

Results: This study highlights inequalities in site-specific cancer mortality, both related to being employed or not and to the occupational status of the employed population. Unemployed men show consistently higher cancer mortality compared with the working groups, irrespectively of the occupation they are in. Also within the employed group, inequalities are observed. Male manual workers have the highest site-specific cancer mortality rates whereas white-collar workers and agricultural and fishery workers have the lowest cancer mortality rates. These inequalities are manifest for all preventable cancer sites (except for non-malignant melanoma), with alcohol- and smoking related cancers being the main contributors of these inequalities.

Conclusions: Important SE inequalities in site-specific cancer mortality were observed by occupational status. Ensuring financial security for the unemployed is a key issue in this regard. Future studies could also take a look at other working regimes, for instance temporary employment or part-time employment, and their relation to health.

Article summary

Strengths and limitations of this study

- Detailed research on occupational inequalities in site-specific cancer mortality is scarce, and even non-existent in Belgium. Yet, although various indicators of socioeconomic position (SEP) are strongly related, they may represent different aspects, and therefore it is important to establish the role of every single dimension of SEP, for every cancer site separately.
- This paper probes into socioeconomic differences in site-specific cancer mortality, using occupational status as a measure of SEP, accounting for two other SEP indicators (education and housing).
- The findings are based upon an exhaustive dataset including the total Belgian population within the economically active age range, which provides very rich information on sociodemographic as well as socioeconomic variables and mortality for a follow-up period of 11 years.
- However, these register data do not contain information on incidence or survival, nor on health behaviours, health care use, or important aspects of the job (e.g. occupational exposures, psychosocial factors), which are all likely to be associated with cancer outcomes. Hence, it is difficult to make solid conclusions on the relative importance of all these factors to explain the observed SE inequalities in cancer mortality.

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INTRODUCTION

In industrialized countries, life expectancy increased during the epidemiological transition, with the most important causes of death (COD) shifting from infectious to chronic diseases such as cancer [1]. This favourable longevity trend went together with an increase in socioeconomic (SE) mortality differences. Socioeconomic position (SEP) became a fundamental cause of health inequalities in general [2,3] and of cancer inequalities in particular [4]. According to the fundamental cause theory (FCT), inequalities result from the differential distribution of valuable resources that can be used to avoid adverse health outcomes [2]. This implies that SE inequalities in health will be larger for cancers that are more preventable, either by avoiding risk behaviour or by access to medical interventions [3,5], than for less or non-preventable cancers.

SE inequalities in health are one of the most important challenges for public health policies. Therefore, it is crucial to thoroughly document these inequalities. Up till now, most studies assessing health inequalities have used only one indicator of SEP, most often educational attainment or material wealth. However, detailed research on occupational inequalities in site-specific cancer mortality is scarce [6,7], and even non-existent in Belgium. Yet, many studies have shown that, although these SEP indicators are strongly related, they may represent different aspects of SEP [8–10]. Therefore, it is important to establish the role of every single dimension of SEP, for every cancer site separately [9,11,12].

Hence, this paper probes into SE differences in site-specific cancer mortality, using occupational status as a measure of SEP, accounting for the other SEP indicators. First, we aim to examine the magnitude of the association between site-specific cancer mortality and occupational status, net of one's educational attainment and housing conditions. Secondly, we want to assess whether these mortality inequalities by occupational status are more pronounced for preventable cancer sites.

DATA AND METHODS

Design and study population

Data were derived from a record linkage between the Belgian censuses of 1991 and 2001 and register data on emigration and mortality for the follow-up period 01/10/2001-31/12/2011. This unique population-based dataset includes information on mortality, emigration, COD, sociodemographic (SD) and SE variables of the total de jure population of Belgium.

All SD and SE variables are extracted from the 2001 census, apart from occupational status for which the 1991 census contains the most recent detailed information. The study population contains all Belgians within the economically active age range (25-65 years) at the census of 1991, for whom information on occupational status was available. The study population included 2,410,147 Belgian women of whom 51% is employed, and 2,311,808 Belgian men, of whom 80% is employed.

Variables

All cancer sites representing at least one per cent of total cancer mortality were included. Table 1 gives an overview of these cancer sites, the corresponding ICD-10 codes, and the level of preventability. To classify the cancers by level of preventability, we apply the criteria used in Mackenbach's study [13]: amenability to behavioural change and to medical interventions. Cancer sites are amenable to behavioural change if the combined population attributable fraction of mortality for overweight and obesity, low fruit and vegetable intake, physical inactivity, unsafe sex, smoking and alcohol consumption was larger than 50% for the European population in the Global Burden of Disease and Risk Factors study [14]. Cancer sites are considered as amenable to medical interventions, if the 5-year relative survival rate for Belgian women and men in the EUROCARE project was higher than 70% between 2000 and 2007 [15] and/or if effective screening is available in Belgium [16].

Table 1. Cancer sites by ICD-10 classification and level of preventability

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		Preventable	
	ICD-10	**Men**	**Women**
Malignant neoplasms of:			
Head and neck	C00-C14, C30-C32	Yes	-
Oesophagus	C15	Yes	Yes
Stomach	C16	Yes	No
Colorectum and anus	C18-C21	Yes	Yes
Liver	C22	Yes	No
Pancreas	C25	No	No
Lung, bronchus and trachea	C33-C34	Yes	Yes
Breast	C50	-	Yes
Cervix uteri	C53	-	Yes
Uterus	C54-C55	-	Yes
Ovary	C56	-	No
Prostate	C61	Yes	-
Kidney	C64-C66, C68	No	No
Bladder	C67	Yes	Yes
Eye, brain and central nervous system	C69-C72	No	No
Malignant melanoma	C43-C44	Yes	Yes
Non-Hodgkin Lymphoma	C82-C85	No	No
Multiple myeloma	C90	No	No
Leukaemia	C91-C95	No	No

The empty cells are cancer sites not included for either men or women.

This study probes into cancer mortality inequality among the Belgian population within the economically active age range by using occupational status as a measure of SEP. The occupational status was derived from the 1991 census and mortality was followed up for the period 2001-2011. Occupational status was classified into nine broad groups. Six of them belong to the employed population and are classified based on the International Standard Classification of Occupations (see table 2) [17]: managers and professionals; intermediate white-collar workers; service and sales workers; agricultural and fishery workers; skilled manual workers; and unskilled manual workers. The unemployed people are divided in three groups: housekeepers; unemployed and 'other' (i.e. students, conscripts for the national service, armed forces, rentiers and disabled people). Because the low number of male housekeepers and female agricultural and fishery workers, these categories are excluded from the analyses. Age was included as a time-varying covariate to account for age changes during the 11-year follow-up period. To do so, individual follow-up time was split into episodes of 5-year attained age groups using Lexis expansions [18].

Statistical analyses

To obtain a full picture of inequalities in cancer mortality, we calculated both absolute and relative measures [19], using complete-case analysis. First, directly age-standardized site-specific mortality rates (ASMR) by occupational status were calculated, using the Belgian population at the 2001 census as standard population. Secondly, mortality rate ratios (MRR) were calculated using Poisson regression. We aimed to assess the net effect of occupational status on cancer mortality. Therefore, the Poisson models were adjusted for educational attainment and housing conditions. Educational attainment was categorized using the International Standard Classification of Education: lower secondary education or less (ISCED 0-

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2, "low"), higher secondary education (ISCED 3-4, "mid"), and tertiary education (ISCED 5-6, "high"). Housing conditions is the result of a combination of ownership (tenant or owner) and comfort of the house (low-, mid- and high-comfort), resulting in six categories [20]. Sensitivity analyses were additionally conducted without adjustment for education and housing conditions. These results are not shown but available upon request. Important differences between the crude and net model are mentioned in the discussion section. As there is a strong association in Belgium between mortality and region [21], as well as migration history [22], all Poisson models were adjusted for region (Flanders, Wallonia and Brussels) and migrant background (native versus non-native). All analyses were stratified by sex and have been performed using STATA 13.1.

RESULTS

Description of the study population

The study population consists of almost 5 million Belgians that have reached the economically active age range (Table 2). Almost four out of five men are employed, whereas in women about 45% has a paid job and approximately the same percentage is unemployed.

Table 2. Description of the study population

		Men			Women		
			Cancer deaths			Cancer deaths	
ISCO*	Occupational status	Population	N	%	Population	N	%
1-2	Managers and professionals	452,268	8,529	1.89	339,663	3,512	1.03
3-4	Intermediate white-collar workers	432,803	8,114	1.87	384,478	3,761	0.98
5	Service and sales workers	92,369	1,837	1.99	167,625	1,670	1.00
6	Agricultural and fishery workers	52,529	1,352	2.57	17,303	282	1.63
7-8	Skilled manual workers	556,418	10,990	1.98	87,631	858	0.98
9	Unskilled manual workers	163,433	3,560	2.18	147,887	1,848	1.25
	Housekeepers	597	22	3.69	72,808	1,581	2.17
	Unemployed	402,503	26,080	6.48	1,081,932	27,289	2.52
	Other	78,465	2,605	3.32	34,152	850	2.49
	Missing	160,092	4,175	2.61	147,985	2,264	1.53

* ISCO code based on the major groups [17]

Absolute cancer mortality rates by employment status

For almost all preventable cancer sites, men belonging to the unemployed or 'other' category have systematically the higher cancer mortality rates (Table 3). Within the employed men, white-collar workers and agricultural and fishery workers have lower cancer mortality rates compared with manual workers. These results hold true for all preventable cancer sites, except malignant melanoma for which no inequality is observed. For the non-preventable cancer sites, less inequalities are observed, as expected based upon the FCT. Only for pancreatic cancer and leukaemia, the ASMR for unemployed men is higher than for almost all other occupational categories.

For women, the absolute inequalities are less pronounced. Generally, mortality from preventable cancer sites is largest for women who are unemployed or who belong to the 'other' category. Within the employed population there are no inequalities, except for lung cancer mortality which is somewhat more elevated for unskilled manual workers. Neither do we observe an inequality pattern for mortality from non-preventable cancer sites. The only two exceptions are stomach and liver cancer mortality, which is highest among the unemployed women.

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Table 3. Absolute site-specific cancer mortality rates (ASMR and 95% C.I.) (2001-2011) among the Belgian population within the economically active age range, by occupational status in 1991

MEN	Managers and professionals	Intermediate white-collar workers	Service and sales workers	Agricultural and fishery workers	Skilled manual workers	Unskilled manual workers	Unemployed	Other
Preventable cancers								
Head and neck	8.9 (8.0-9.8)	11.0 (9.8-12.2)	15.5 (12.3-18.7)	9.7 (6.9-12.4)	13.3 (12.0-14.6)	18.0 (15.3-20.7)	32.3 (29.7-34.8)	25.0 (20.9-29.1)
Oesophagus	9.4 (8.5-10.4)	9.9 (8.8-11.1)	9.8 (7.4-12.2)	7.2 (4.9-9.5)	10.9 (9.6-12.2)	12.5 (9.8-15.1)	17.1 (15.4-18.8)	14.7 (11.6-17.7)
Stomach	6.7 (5.8-7.5)	7.4 (6.4-8.4)	6.4 (4.1-8.7)	7.4 (5.2-9.6)	10.7 (9.2-12.2)	11.3 (8.6-14.1)	12.4 (11.1-13.6)	14.9 (11.8-18.0)
Colorectal	23.4 (21.8-25.0)	25.6 (23.5-27.7)	28.5 (23.2-33.8)	19.3 (15.8-22.9)	28.3 (25.8-30.8)	28.9 (24.5-33.4)	31.5 (29.7-33.4)	31.7 (27.2-36.1)
Liver	8.6 (7.7-9.6)	7.2 (6.2-8.2)	9.0 (6.0-12.1)	2.6 (1.3-4.0)	6.8 (5.7-7.9)	8.9 (6.7-11.1)	11.6 (10.2-12.9)	11.2 (8.5-13.8)
Lung	62.7 (60.1-65.3)	80.5 (76.9-84.1)	110.1 (100.0-120.2)	80.7 (73.4-88.1)	113.7 (109.1-118.2)	118.0 (110.2-125.9)	154.0 (149.5-158.6)	166.7 (156.5-176.9)
Prostate	15.8 (14.4-17.2)	17.0 (15.0-18.9)	18.5 (13.8-23.2)	16.2 (13.1-19.3)	18.4 (16.0-20.7)	17.5 (13.9-21.1)	18.8 (17.7-19.9)	26.0 (22.0-30.0)
Bladder	6.7 (5.8-7.6)	8.6 (7.3-9.8)	10.5 (7.1-13.9)	5.4 (3.6-7.3)	8.1 (6.8-9.4)	12.1 (9.2-15.1)	12.6 (11.4-13.7)	16.0 (12.8-19.1)
Malignant melanoma	3.1 (2.6-3.7)	3.0 (2.4-3.6)	4.4 (2.5-6.2)	3.4 (1.8-5.0)	2.5 (2.0-3.1)	2.1 (1.4-2.8)	2.4 (1.9-3.0)	3.1 (1.8-4.5)
Non-preventable cancers								
Pancreas	13.9 (12.7-15.1)	12.8 (11.3-15.1)	16.0 (11.9-20.0)	13.0 (10.0-16.0)	12.5 (11.0-14.0)	13.9 (11.1-16.7)	17.5 (16.0-19.0)	18.1 (14.7-21.5)
Kidney	7.5 (6.6-8.4)	8.3 (7.1-9.4)	6.7 (4.6-8.8)	6.4 (4.4-8.5)	8.0 (6.7-9.3)	7.3 (5.2-9.4)	8.8 (7.7-9.8)	11.4 (8.7-14.2)
Eye, nervous system	7.4 (6.6-8.3)	7.6 (6.6-8.5)	8.9 (6.0-11.9)	6.0 (3.9-8.0)	6.7 (5.8-7.6)	6.9 (5.0-8.7)	7.6 (6.5-8.6)	9.5 (7.0-11.9)
Non-Hodgkin lymphoma	6.0 (5.2-6.8)	6.3 (5.2-7.4)	7.3 (4.5-10.0)	7.8 (5.5-10.2)	6.9 (5.6-8.2)	4.2 (2.8-5.6)	7.6 (6.6-8.5)	7.6 (5.4-9.8)
Multiple myeloma	3.4 (2.8-4.0)	4.2 (3.3-5.0)	4.1 (1.8-6.4)	4.6 (2.9-6.3)	3.4 (2.6-4.2)	4.6 (2.8-6.4)	4.1 (3.5-4.7)	4.6 (2.9-6.4)
Leukemia	7.0 (6.1-7.9)	7.4 (6.2-8.6)	8.9 (6.0-11.8)	8.4 (6.1-10.7)	7.8 (6.4-9.1)	7.4 (5.3-9.6)	9.1 (8.2-10.1)	8.2 (5.9-10.4)

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Table 3 (continued)

WOMEN	Managers and professionals	Intermediate white-collar workers	Service and sales workers	Skilled manual workers	Unskilled manual workers	Housekeepers	Unemployed	Other
Preventable cancers								
Oesophagus	3.5 (2.1-5.0)	2.7 (1.5-3.9)	3.0 (1.5-4.5)	3.4 (0.0-8.6)	3.5 (1.5-5.4)	1.9 (1.0-2.9)	3.1 (2.8-3.4)	3.9 (1.8-6.0)
Colorectal	14.4 (12.1-16.8)	17.2 (14.2-20.3)	15.7 (11.5-19.8)	14.6 (10.5-18.6)	14.1 (10.6-17.6)	16.8 (14.1-19.5)	18.5 (17.8-19.2)	32.8 (24.5-41.1)
Lung	22.4 (19.4-25.3)	22.4 (19.5-25.3)	24.3 (19.1-29.4)	18.5 (14.6-22.4)	29.9 (25.1-34.7)	24.3 (20.9-27.7)	29.7 (28.7-30.8)	51.2 (41.1-61.3)
Breast	41.2 (37.7-44.8)	44.4 (40.0-48.7)	35.3 (30.3-40.4)	37.5 (28.6-46.3)	37.2 (32.0-42.3)	38.7 (33.5-42.2)	42.4 (41.2-43.6)	66.5 (55.0-78.0)
Cervix	3.2 (2.0-4.4)	1.9 (1.4-2.4)	2.3 (1.5-3.0)	2.0 (0.6-3.3)	4.1 (2.1-6.0)	3.6 (2.2-5.1)	4.2 (3.8-4.6)	4.0 (1.1-6.9)
Uterus	5.4 (3.8-6.9)	5.6 (3.7-7.6)	5.5 (3.4-7.7)	11.9 (2.8-20.9)	3.8 (1.9-5.8)	6.2 (4.4-8.0)	6.1 (5.6-6.5)	7.2 (3.8-10.5)
Bladder	1.5 (0.7-2.3)	1.4 (0.5-2.2)	2.7 (0.8-4.6)	1.3 (0.1-2.6)	1.3 (0.6-2.0)	1.6 (0.8-2.5)	2.5 (2.2-2.7)	7.4 (3.4-11.3)
Malignant melanoma	2.1 (1.4-2.8)	2.9 (1.7-4.1)	1.8 (1.0-2.5)	2.4 (1.0-3.8)	2.9 (1.5-4.4)	2.2 (1.2-3.3)	2.4 (2.2-2.7)	1.8 (0.3-3.2)
Non-preventable cancers								
Stomach	2.6 (1.7-3.6)	2.2 (1.4-3.1)	3.6 (1.3-5.8)	2.9 (1.1-4.8)	4.5 (2.8-6.2)	3.7 (2.5-4.9)	4.3 (3.9-4.7)	9.0 (4.3-13.7)
Liver	2.5 (1.5-3.6)	3.2 (1.8-4.7)	2.3 (1.4-3.2)	2.2 (0.4-3.9)	4.0 (2.0-6.0)	4.0 (2.7-5.2)	4.4 (4.0-4.7)	6.2 (2.9-9.4)
Pancreas	11.0 (8.7-13.2)	10.0 (7.0-12.9)	9.3 (6.4-12.3)	6.3 (3.7-9.0)	9.8 (6.9-12.7)	10.3 (8.1-12.5)	10.7 (10.2-11.3)	14.3 (9.1-19.4)
Ovary	11.7 (9.7-13.7)	13.9 (10.6-17.0)	13.7 (9.7-17.6)	14.8 (7.0-22.6)	13.8 (10.3-17.3)	10.7 (8.6-12.8)	12.2 (11.6-12.8)	12.3 (7.7-16.9)
Kidney	3.2 (2.2-4.1)	3.1 (1.7-4.5)	2.2 (1.4-3.1)	2.3 (0.6-4.1)	2.6 (1.1-4.0)	4.2 (2.9-5.5)	4.2 (3.8-4.5)	6.1 (3.6-8.6)
Eye, nervous system	5.4 (4.1-6.6)	4.3 (3.2-5.4)	6.2 (3.5-8.9)	3.1 (1.9-4.3)	6.3 (3.9-8.6)	6.0 (4.2-7.8)	5.4 (5.0-5.8)	10.0 (5.6-14.4)
Non-Hodgkin lymphoma	3.4 (2.1-4.6)	4.0 (2.5-5.5)	3.4 (1.7-5.0)	5.4 (0.1-10.7)	4.0 (2.0-5.9)	4.0 (2.7-5.4)	4.5 (4.2-4.9)	6.9 (2.6-11.3)
Multiple myeloma	3.2 (1.8-4.5)	2.4 (1.2-3.6)	1.7 (0.9-2.5)	1.4 (0.1-2.8)	2.6 (0.8-4.4)	3.6 (2.3-4.8)	3.1 (2.8-3.4)	1.9 (0.5-3.3)
Leukemia	5.5 (3.8-7.1)	3.8 (2.6-5.1)	3.7 (2.1-5.4)	7.4 (1.7-13.2)	5.3 (2.9-7.7)	6.0 (4.4-7.6)	5.0 (4.6-5.3)	8.6 (4.0-13.2)

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Table 4. Net relative site-specific cancer mortality inequality (MRR and 95% C.I.) (2001-2011) among the Belgian population within the economically active age range, by occupational status in 1991

MEN	Managers and professionals	Intermediate white-collar workers	Service and sales workers	Agricultural and fishery workers	Skilled manual workers	Unskilled manual workers	Unemployed	Other
Preventable cancers								
Head and neck	1.00	0.97 (0.86-1.09)	1.11 (0.93-1.33)	0.75 (0.58-0.98)	0.92 (0.81-1.04)	1.26 (1.09-1.47)	2.55 (2.26-2.89)	1.62 (1.35-1.94)
Oesophagus	1.00	0.92 (0.82-1.04)	0.89 (0.72-1.09)	0.73 (0.55-0.96)	0.89 (0.78-1.01)	0.94 (0.79-1.11)	2.07 (1.83-2.36)	1.30 (1.05-1.60)
Stomach	1.00	0.96 (0.84-1.11)	0.87 (0.68-1.12)	0.94 (0.71-1.25)	0.97 (0.84-1.13)	1.03 (0.84-1.25)	2.36 (2.06-2.70)	1.91 (1.54-2.36)
Colorectal	1.00	0.90 (0.83-0.97)	0.83 (0.72-0.96)	0.82 (0.70-0.97)	0.81 (0.75-0.89)	0.86 (0.76-0.97)	1.95 (1.80-2.10)	1.22 (1.06-1.40)
Liver	1.00	0.77 (0.67-0.88)	0.59 (0.45-0.78)	0.27 (0.17-0.43)	0.62 (0.53-0.72)	0.72 (0.58-0.88)	1.47 (1.28-1.69)	1.17 (0.93-1.48)
Lung	1.00	0.99 (0.95-1.04)	1.09 (1.01-1.17)	1.00 (0.92-1.09)	1.11 (1.06-1.16)	1.10 (1.04-1.17)	2.56 (2.45-2.67)	1.90 (1.78-2.03)
Prostate	1.00	0.91 (0.82-1.01)	0.90 (0.73-1.09)	1.23 (1.03-1.47)	0.82 (0.73-0.92)	0.94 (0.80-1.10)	2.21 (2.01-2.44)	1.68 (1.43-1.99)
Bladder	1.00	0.97 (0.83-1.12)	1.03 (0.79-1.33)	0.84 (0.62-1.14)	0.95 (0.81-1.11)	1.23 (1.00-1.50)	2.87 (2.50-3.30)	1.88 (1.50-2.36)
Malignant melanoma	1.00	0.91 (0.75-1.11)	1.24 (0.91-1.70)	1.23 (0.84-1.80)	0.62 (0.49-0.78)	0.72 (0.53-0.99)	1.48 (1.18-1.84)	0.76 (0.49-1.18)
Non-preventable cancers								
Pancreas	1.00	0.91 (0.82-1.01)	0.91 (0.75-1.09)	1.05 (0.86-1.29)	0.82 (0.73-0.92)	0.88 (0.75-1.03)	1.91 (1.72-2.12)	1.26 (1.05-1.51)
Kidney	1.00	0.94 (0.82-1.07)	0.85 (0.66-1.10)	0.85 (0.64-1.13)	0.77 (0.66-0.89)	0.64 (0.51-0.80)	1.72 (1.50-1.97)	1.56 (1.25-1.95)
Eye, nervous system	1.00	0.94 (0.83-1.08)	0.91 (0.72-1.15)	0.97 (0.73-1.29)	0.74 (0.64-0.86)	0.73 (0.59-0.91)	1.49 (1.28-1.74)	1.17 (0.92-1.49)
Non-Hodgkin lymphoma	1.00	0.87 (0.74-1.02)	1.04 (0.79-1.36)	1.36 (1.03-1.81)	0.86 (0.73-1.02)	0.75 (0.58-0.97)	1.92 (1.64-2.24)	1.02 (0.75-1.38)
Multiple myeloma	1.00	1.13 (0.93-1.37)	0.73 (0.48-1.13)	1.74 (1.23-2.45)	0.90 (0.72-1.13)	1.00 (0.73-1.37)	2.50 (2.06-3.05)	1.44 (0.99-2.09)
Leukemia	1.00	0.96 (0.83-1.12)	1.18 (0.91-1.52)	1.41 (1.08-1.83)	0.95 (0.81-1.12)	1.01 (0.81-1.27)	2.28 (1.98-2.64)	1.18 (0.89-1.55)

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Table 4 (continued)

WOMEN	Managers and professionals	Intermediate white-collar workers	Service and sales workers	Skilled manual workers	Unskilled manual workers	Housekeepers	Unemployed	Other
Preventable cancers								
Oesophagus	1.00	0.94 (0.67-1.31)	1.12 (0.74-1.68)	0.58 (0.31-1.09)	1.02 (0.67-1.56)	1.28 (0.81-2.02)	1.56 (1.15-2.13)	1.72 (0.97-3.05)
Colorectal	1.00	1.06 (0.94-1.21)	0.88 (0.74-1.04)	1.12 (0.92-1.37)	0.88 (0.74-1.05)	1.27 (1.07-1.51)	1.62 (1.45-1.80)	1.97 (1.58-2.45)
Lung	1.00	0.95 (0.86-1.05)	0.91 (0.80-1.03)	0.88 (0.75-1.03)	0.97 (0.86-1.10)	1.22 (1.06-1.41)	1.41 (1.29-1.55)	1.55 (1.30-1.85)
Breast	1.00	0.98 (0.91-1.05)	0.80 (0.73-0.89)	0.83 (0.74-0.94)	0.81 (0.73-0.90)	1.12 (1.01-1.25)	1.36 (1.27-1.45)	1.52 (1.32-1.75)
Cervix	1.00	0.85 (0.62-1.16)	0.90 (0.61-1.31)	0.65 (0.40-1.05)	0.98 (0.67-1.42)	1.27 (0.82-1.96)	1.67 (1.26-2.21)	0.88 (0.45-1.73)
Uterus	1.00	0.97 (0.75-1.26)	1.16 (0.86-1.57)	0.97 (0.64-1.47)	0.75 (0.53-1.07)	1.25 (0.90-1.75)	1.93 (1.55-2.39)	1.60 (1.03-2.49)
Bladder	1.00	0.82 (0.53-1.27)	1.33 (0.81-2.17)	1.28 (0.68-2.44)	1.13 (0.67-1.90)	1.11 (0.65-1.89)	1.93 (1.42-2.66)	3.45 (1.97-6.05)
Malignant melanoma	1.00	1.14 (0.87-1.49)	0.76 (0.54-1.13)	1.16 (0.76-1.76)	1.18 (0.83-1.68)	0.99 (0.62-1.58)	1.33 (1.04-1.71)	0.87 (0.42-1.80)
Non-preventable cancers								
Stomach	1.00	1.03 (0.77-1.39)	0.86 (0.59-1.25)	0.85 (0.53-1.35)	1.54 (1.11-2.12)	1.37 (0.95-1.98)	1.71 (1.33-2.20)	2.19 (1.39-3.44)
Liver	1.00	0.82 (0.60-1.13)	0.65 (0.43-0.99)	0.74 (0.43-1.26)	1.07 (0.74-1.54)	1.52 (1.06-2.17)	1.76 (1.37-2.26)	1.26 (0.73-2.17)
Pancreas	1.00	0.86 (0.73-1.01)	0.82 (0.66-1.01)	0.78 (0.58-1.04)	0.94 (0.76-1.16)	1.17 (0.94-1.45)	1.44 (1.25-1.64)	1.34 (0.98-1.83)
Ovary	1.00	0.85 (0.74-0.99)	0.91 (0.75-1.10)	0.95 (0.75-1.20)	0.90 (0.74-1.09)	1.14 (0.93-1.40)	1.36 (1.20-1.55)	0.99 (0.71-1.37)
Kidney	1.00	0.63 (0.47-0.85)	0.77 (0.53-1.12)	0.65 (0.39-1.07)	0.62 (0.42-0.93)	1.23 (0.86-1.75)	1.41 (1.12-1.78)	2.25 (1.49-3.42)
Eye, nervous system	1.00	0.74 (0.61-0.91)	0.80 (0.62-1.03)	0.71 (0.51-0.99)	0.69 (0.52-0.91)	1.18 (0.89-1.56)	1.11 (0.94-1.32)	0.-89 (0.56-1.42)
Non-Hodgkin lymphoma	1.00	1.04 (0.79-1.38)	0.82 (0.57-1.19)	1.18 (0.77-1.83)	0.86 (0.60-1.25)	1.83 (1.32-2.52)	1.71 (1.36-2.15)	1.35 (0.80-2.27)
Multiple myeloma	1.00	1.09 (0.78-1.52)	1.07 (0.68-1.67)	0.86 (0.44-1.65)	0.95 (0.60-1.52)	2.12 (1.44-3.12)	2.11 (1.60-2.78)	1.22 (0.58-2.55)
Leukemia	1.00	0.95 (0.75-1.22)	0.88 (0.63-1.22)	0.98 (0.66-1.48)	1.05 (0.77-1.43)	1.53 (1.13-2.08)	1.43 (1.16-1.75)	1.22 (0.76-1.97)

Reference category is managers and professionals
All analyses are adjusted for current age, region, migrant background, educational attainment and housing conditions

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Relative cancer mortality inequality by employment status

In this paragraph, we present the results of the net relative models, adjusted for education and housing conditions. Unemployed men and women have higher cancer mortality rates compared with employed people, independently of the occupation they are in (Table 4). This holds true for preventable and non-preventable cancers. To illustrate this with an example, unemployed men have an almost three times higher chance of dying from bladder cancer (MRR: 2.87; 95% C.I.: 2.50-3.30) compared with male managers. For most cancer sites and especially the preventable cancers, men and women belonging to the 'other' category (of mainly disabled persons and conscripts) also have consistently higher cancer mortality rates compared with the managerial group. Moreover, female housekeepers also died more often from some cancers (e.g. colorectal, lung, and breast).

Among the employed groups, inequalities are also observed, although more in men than in women (Table 4). In men, managers appear to have higher colorectal and liver cancer mortality rates compared with men in other jobs. Furthermore, lower mortality rates in favour of manual workers are observed for several non-preventable cancer sites, amongst others cancer of the pancreas and kidney. Compared with male managers, both sales and service workers and manual workers have a 10% higher lung cancer mortality rate. Women belonging to these three occupational groups have a 20% lower breast cancer mortality rate compared with female managers. Another interesting observation is the mortality pattern of the agricultural and fishery workers. Compared with managers, they tend to die less from preventable cancers such as head and neck and oesophageal cancers. Their liver cancer mortality rate is even 73% lower compared with managers (MRR: 0.27; 95% C.I.: 0.17-0.43). In contrast, agricultural and fishery workers show higher mortality from some non-preventable cancer sites such as leukaemia and multiple myeloma. The exception is however prostate cancer, which is classified as preventable but for which they show higher mortality (MRR: 1.23; 95% C.I. 1.03-1.47).

DISCUSSION AND CONCLUSION

Methodological issues

The findings are based upon a high-quality and exhaustive dataset including the total Belgian population within the economically active age range. A numerator-denominator bias was eliminated through record linkage between census and register data. This dataset provides very rich information on SD as well as SE variables and mortality for a follow-up period of 11 years. This enables us to give precise estimates of site-specific cancer mortality inequalities at the individual level. However, these register data do not contain information on incidence or survival, nor on health behaviours, health care use, or important aspects of the job (e.g. occupational exposures, psychosocial factors), which are all likely to be associated with cancer outcomes [23]. Therefore it is difficult to make solid conclusions on the relative importance of all these factors to explain the observed SE inequalities in cancer mortality [23,24].

We included the total Belgian population that belonged to the economically active age group (25-65 years) at the census of 1991, independently of their actual occupational status. By doing so, we avoided a selection effect due to including only the healthy workers [6,25–28]. Our results indicate the importance of this issue, showing highest site-specific cancer mortality among the inactive groups (both unemployed or disabled). Nevertheless, we cannot fully exclude a selection effect because we can assume that unhealthy persons are less frequently employed in physically demanding jobs [26,27]. A healthy worker effect might then be more likely in the groups of manual workers, which could partly explain some of the observed mortality patterns in favour of manual workers. On the other hand, the white-collar workers may have less physically demanding jobs, which can counter this effect. Occupational information was derived from the census of 1991, which is the most recent source of detailed information since the census of 2001 does not contain detailed occupational information. Because of the lag time between some (occupational) exposures and cancer mortality, we do not consider this as a problem [29]. Due to the cross-sectional nature of this information, the occupation is not necessarily the longest job respondents were involved in, nor do we have

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information on the duration of this occupation [25]. However, occupation was grouped into broad groups, which leads us to assume that the bias due to transitions between occupational categories will be rather small [30].

We decided not to use the robust distinction between manual versus non-manual workers, nor did we focus on one specific cancer site in relation to one or more job exposures. These choices have been made in order to gain insights into the overall association between occupational status and cancer mortality [26]. Many studies assessing SE inequalities in cancer mortality use only one SE indicator at a time although the importance of including multiple indicators has already been pointed out [9,11,12] because different SEP indicators tap into different pathways [8–10]. Housing conditions are related to material and financial resources, and therefore to healthcare utilisation [31]. Education captures the human capital acquired early in life and may be related to the ability to adapt health education messages, and hence to health behaviours [6]. Occupational status on the other hand reflects the ability to realize this human capital in the labour market, and is rather a reflection of one's social class at older ages. Occupation is likely to (partially) capture material resources, access to health care as well as social networks and work-related factors such as stress, autonomy and occupational hazards. Hence, we need to analyse all aspects of SEP in relation to health outcomes, although these indicators are closely related. In this paper we focus on the net effect of occupational status, thereby adjusting for educational attainment and housing conditions. The results indicate an association between occupational status and site-specific cancer mortality, independently of education and housing conditions.

Finally, we classified the cancer sites by their level of preventability (see Methods). We acknowledge that this classification does not exclude the fact that some "non-preventable" cancers are also related to behavioural change and/or medical interventions, nor does it eliminate some possible overlap between these two criteria of preventability. However, to enhance the comparability with other studies, we decided to adopt this often-used classification.

Theoretical considerations on the main findings

This study reveals inequalities in site-specific cancer mortality by occupational status. Generally, SE inequalities are less pronounced in women compared with men, which is consistent with the literature [7,23,28]. The unemployed and 'other' group show, both for men and women, higher cancer mortality rates compared with the working groups, irrespectively of the occupation they are in, which is in line with previous studies [23,32]. Possible explanations are financial insecurity, which is related to a lower use of health care services, as well as an unhealthy lifestyle [32]. Some studies suggest that part of this association between unemployment and health might be due to health selection [23], although others observed an ongoing effect after adjustment for pre-existing morbidity [32]. However, it is very likely that for the 'other' group, which consists mainly of disabled people, health selection will be at play.

A considerable part of the women in our study population is not active on the labour market but is a housekeeper. In absolute terms, we did not observe mortality differences compared with the other occupations, except for some lower site-specific mortality rates compared with the 'other' group. However, after adjusting for education and housing conditions, they did have higher mortality for e.g. cancers of the colorectum, breast and lung, compared with the highest occupations. It is likely that for these housekeepers, due to the lack of job income, housing conditions (which is an indicator of the SEP of the partner and the household) might be a more important determinant for health outcomes [31,33].

Also within the employed group, inequalities by occupational group are observed. In men these findings are in line with the FCT which expects larger inequalities for more preventable cancer sites [3,5]. When there is sound knowledge of the causes and cures of cancers, those in high SEP contexts, with greater access to resources, will disproportionally benefit from this knowledge. The absolute results show that male manual workers have the highest site-specific cancer mortality rates whereas white-collar workers and agricultural and fishery workers have the lowest cancer mortality rates. This discrepancy between manual and non-manual workers is in

line with the literature [6,34]. These inequalities are manifest for all preventable cancer sites (except for non-malignant melanoma), with alcohol- and smoking-related cancers (e.g. cancers of the lung, head and neck and bladder) being the main contributors to these inequalities, as reported in previous studies [25,28,30,34,35]. The excess mortality for cancers of the head and neck and lung are also observed for male service and sales workers, which can be explained by the higher likelihood of occupational exposure to tobacco and alcohol in bars and restaurants [27]. Another interesting finding is the favourable cancer mortality pattern for farmers, which might be related to their healthy life style with less tobacco and alcohol use and more physical activity [36,37].

According to Link and Phelan, the availability of valuable resources such as knowledge, money, power, prestige and beneficial social connections are the social causes of health inequalities [2]. Several mechanisms have been suggested to explain this association, such as a differential acquisition of knowledge on health-damaging behaviours (e.g. smoking, bad diet, alcohol intake or a lack of exercise) [6,7,10,23,26,38]. Also material factors are important: having financial difficulties might be related to poor living conditions [7,23,30] or the inability to optimise the use of health services [10,34,38]. Both access to and quality of health care are crucial for health outcomes in all stages, from prevention to treatment. Finally, the social aspect of SEP is associated with health, for example stress-related factors or the level of social prestige [25]. Since we cannot adjust for health behaviours or health care use, it remains difficult to decide on the extent of inequalities due to each of these mechanisms [26]. Previous studies mediating the observed gradients for smoking reported an attenuated but still significant relation between SEP and mortality [7,24,30], which assumes that there might be other factors at play as well. After adjusting for education and housing conditions, the social gradient in male lung cancer remained with higher mortality for manual and service workers, whereas in women the higher lung cancer mortality for unskilled manual workers disappeared. In contrary, in the adjusted model higher breast cancer mortality rates were observed in female managers compared with sales and service workers and manual workers. This has also been observed in previous studies and can be explained by differences in reproductive behaviour, with less children and a later age at first birth for the white-collar occupations [24,28]. In the net model, male managers had higher colorectal and liver cancer mortality compared with all other occupations. Moreover, compared with the white-collar occupations, manual workers do have lower mortality for several other cancer sites (e.g. malignant melanoma and kidney). These results are counterintuitive, suggesting that there are other factors at play, such as an unhealthy and sedentary lifestyle of managers [39,40].

We can assume that the results of the net model are more likely to be due to differences related to the job itself. Yet, a healthy lifestyle may be induced by the social environment (e.g. the colleagues at work), and therefore might not be excluded as a potential mechanism [6]. Specific occupational exposures and hazards may explain part of the association between occupational status and health [7,10,23]. This could for example explain the excess lung cancer mortality in service and sales workers as well as in manual workers, the first due to tobacco smoke exposure [27], and the latter due to exposure to several occupational carcinogens linked with lung cancer [7,10,23]. Another important aspect of work related to health is the psychosocial aspect of the job, such as the sense of control and autonomy, the level of job strain, or long working hours [7,23,25,30,41]. This could be an explanation for the excessive colorectal cancer mortality among male managers. Colorectal cancer is associated with perceived stress, and could therefore be related to the long working hours and work strain as perceived by managers [39,41].

Implications and conclusions

This paper highlights important SE inequalities in site-specific cancer mortality by occupational status. These occupational inequalities change when other SEP indicators are adjusted for. Multiple SEP indicators should be taken into account when studying SE inequalities in health [9,11,12] because these allow for different causal pathways [8–10]. Yet, it is difficult to identify

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to what extent the potential explanatory factors attribute to these inequalities because we do not dispose of data on incidence or survival, nor on data on risk factors, health care use, or job characteristics. Future studies having access to these kind of data could help to unravel the complex interplay between incidence, survival and mortality, and to clarify at which steps the social differences operate [23,24].

This study can be helpful in providing evidence for policy makers in order to reduce SE inequalities in cancer mortality [38]. Our results prove that there is still a long way to go. We observed for example that the unemployed groups are at a much higher risk of dying from cancer compared with the employed population. Ensuring financial security for the unemployed is a key issue in this regard [32]. Future research could also study other working regimes, e.g. temporary or part-time employment, and their relation to health. Finally, there could be an important role for the general practitioner to make sure that the unemployed are getting the health care they need [32]. Also for the high-risks jobs, regular health checks at the work floor are needed in order to detect cancers at an early stage.

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Competing interests

We have read and understood the BMJ policy on the declaration of interests and declare that we have no competing interests.

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Authors' contributions

KV designed and conducted the study and wrote the first draft of the manuscript. LVdB, HV, PH and SG helped with the interpretation of the results and critically revised this first draft. KV, LvDB, HV, PH and SG approved the final version of the manuscript.

Data sharing statement

Analyses are based on administrative data from the Belgian Census, the Belgian mortality register and death certificates provided by Statistics Belgium. The availability of the data is restricted. Permission for analyses must be granted after verification of the research goals by the Belgian Commission for the protection of privacy.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	p. 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	p. 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	p. 3
Objectives	3	State specific objectives, including any prespecified hypotheses	p. 3
Methods			
Study design	4	Present key elements of study design early in the paper	p. 3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	p. 3
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	p. 3
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	p. 3
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	p. 3-4
Bias	9	Describe any efforts to address potential sources of bias	p. 5
Study size	10	Explain how the study size was arrived at	p. 3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	p. 3-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	p. 4-5
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	p. 4
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	p. 5
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	p. 5
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	p. 5
		(b) Indicate number of participants with missing data for each variable of interest	p. 5
		(c) Summarise follow-up time (eg, average and total amount)	p. 5
Outcome data	15*	Report numbers of outcome events or summary measures over time	p. 5
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	p. 5-10
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	p. 11-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	p. 11-12
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	p.10-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	p.10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	p. 13

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Site-specific cancer mortality inequalities by employment and occupational groups: a cohort study among Belgian adults, 2001-2011

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Site-specific cancer mortality inequalities by employment and occupational groups: a cohort study among Belgian adults, 2001-2011

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Abstract

Objective: This study probes into site-specific cancer mortality inequalities by employment and occupational group among Belgians, adjusted for other indicators of socioeconomic position.

Design: This cohort study is based on record linkage between the Belgian censuses of 1991 and 2001 and register data on emigration and mortality for 01/10/2001-31/12/2011.

Setting: Belgium

Participants: The study population contains all Belgians within the economically active age (25-65 years) at the census of 1991.

Outcome measures: Both absolute and relative measures were calculated. First, age-standardized mortality rates (ASMR) have been calculated, directly standardized to the Belgian population. Secondly, mortality rate ratios were calculated using Poisson regression, adjusted for education, housing conditions, attained age, region and migrant background.

Results: This study highlights inequalities in site-specific cancer mortality, both related to being employed or not and to the occupational group of the employed population. Unemployed men and women show consistently higher overall and site-specific cancer mortality compared with the employed group. Also within the employed group, inequalities are observed by occupational group. Generally manual workers and service and sales workers have higher site-specific cancer mortality rates compared with white-collar workers and agricultural and fishery workers. These inequalities are manifest for almost all preventable cancer sites, especially those cancer sites related to alcohol- and smoking such as cancers of the lung, oesophagus and head and neck. Overall, occupational inequalities were less pronounced among women compared to men.

Conclusions: Important socioeconomic inequalities in site-specific cancer mortality were observed by employment and occupational group. Ensuring financial security for the unemployed is a key issue in this regard. Future studies could also take a look at other working regimes, for instance temporary employment or part-time employment, and their relation to health.

Article summary

Strengths and limitations of this study

- This paper probes into socioeconomic differences in site-specific cancer mortality, using employment and occupational group as measures of SEP, accounting for two other SEP indicators (education and housing conditions).
- The findings are based upon an exhaustive dataset including the total Belgian population within the economically active age range, which provides very rich information on sociodemographic as well as socioeconomic variables and mortality for a follow-up period of 11 years.
- These administrative register data do not contain information on incidence or survival, nor on health behaviours, health care use, or important aspects of the job (e.g. occupational exposures, psychosocial factors).

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INTRODUCTION

In industrialized countries, life expectancy increased during the epidemiological transition, with the most important causes of death (COD) shifting from infectious to chronic diseases such as cancer [1]. This favourable longevity trend went together with an increase in socioeconomic (SE) health inequalities in general [2,3] and with cancer inequalities in particular [4]. According to the fundamental cause theory (FCT), inequalities result from the differential distribution of valuable resources that can be used to avoid adverse health outcomes [2]. This implies that SE inequalities in health will be larger for cancers that are more preventable, either by avoiding risk behaviour or by access to medical interventions [3,5], than for less or non-preventable cancers.

SE inequalities in health are one of the most important challenges for public health policies. Therefore, it is crucial to thoroughly document these inequalities. Up till now, most studies assessing health inequalities have used only one indicator of SEP, most often educational attainment or material wealth. However, detailed research on occupational inequalities in site-specific cancer mortality is scarce [6,7], and even non-existent in Belgium. Yet, many studies have shown that, although these SEP indicators are strongly related, they may represent different aspects of SEP [8–10]. Therefore, it is important to establish the role of every single dimension of SEP, for every cancer site separately [9,11,12].

Hence, this paper probes into SE differences in site-specific cancer mortality, using employment and occupational group as measures of SEP, accounting for the other SEP indicators. By doing so, we aim to estimate the net association between employment and occupational group and site-specific cancer mortality in Belgium, which has not yet been studied. Our first research aim is to examine the magnitude of the association between site-specific cancer mortality and employment group, net of one's educational attainment and housing conditions. The second research aim is to assess whether among the employed group, occupational group is associated with site-specific cancer mortality, again net of education and housing conditions. Based on the FCT, we assume that we will observe inequalities by employment and occupational status, especially for the more preventable cancer sites.

DATA AND METHODS

Design and study population

Data are derived from a record linkage between the Belgian censuses of 1991 and 2001 and register data on emigration and cause-specific mortality for the follow-up period 01/10/2001-31/12/2011. This unique population-based dataset includes information on mortality, emigration, COD, sociodemographic (SD) and SE variables of the total de jure population of Belgium.

All SD and SE variables are extracted from the 2001 census, apart from occupational status for which the 1991 census contains the most recent detailed information. All Belgian individuals who are alive at the 2001 census, and who were within the economically active age range (25-65 years) at the census of 1991 are included in the study. For these individuals, we linked information on employment and occupational status, stemming from the 1991 census, irrespective of their employment status at the 2001 census. The study population includes 2,333,479 Belgian women of whom 49% is employed, and 2,231,385 Belgian men, of whom 80% is employed. Age is included as a time-varying covariate to account for age changes during the 11-year follow-up period. To do so, individual follow-up time is split into episodes of 5-year attained age groups using Lexis expansions [13]. Consequently, the age distribution of this population ranges from 35 to 85 years.

Variables

All cancer sites representing at least one per cent of the total cancer mortality are included. Table 1 gives an overview of these cancer sites, the corresponding ICD-10 codes, and the level of preventability. To classify the cancers by level of preventability, we apply the criteria used in Mackenbach's study [14]: amenability to behavioural change and to medical interventions.

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Cancer sites are amenable to behavioural change if the combined population attributable fraction of mortality for overweight and obesity, low fruit and vegetable intake, physical inactivity, unsafe sex, smoking and alcohol consumption was larger than 50% for the European population in the Global Burden of Disease and Risk Factors study [15]. Cancer sites are considered as amenable to medical interventions, if the 5-year relative survival rate for Belgian women and men in the EUROCARE project was higher than 70% between 2000 and 2007 [16] and/or if effective screening is available in Belgium [17].

Table 1. Cancer sites by ICD-10 classification and level of preventability

		Preventable	
	ICD-10	**Men**	**Women**
Malignant neoplasms of:			
Head and neck	C00-C14, C30-C32	Yes	-
Oesophagus	C15	Yes	Yes
Stomach	C16	Yes	No
Colorectum and anus	C18-C21	Yes	Yes
Liver	C22	Yes	No
Pancreas	C25	No	No
Lung, bronchus and trachea	C33-C34	Yes	Yes
Breast	C50	-	Yes
Cervix uteri	C53	-	Yes
Uterus	C54-C55	-	Yes
Ovary	C56	-	No
Prostate	C61	Yes	-
Kidney	C64-C66, C68	No	No
Bladder	C67	Yes	Yes
Eye, brain and central nervous system	C69-C72	No	No
Malignant melanoma	C43-C44	Yes	Yes
Non-Hodgkin Lymphoma	C82-C85	No	No
Multiple myeloma	C90	No	No
Leukaemia	C91-C95	No	No

The empty cells are cancer sites not included for either men or women.

This study probes into cancer mortality inequality among the Belgian population within the economically active age range by using employment and occupational group as a measure of SEP. Both employment and occupational status are derived from the 1991 census and mortality is followed up for the period 2001-2011. Employment status is divided in four categories: employed; unemployed and looking for a job; unemployed and not looking for a job; and disabled. Among the employed, we additionally defined their occupational group, based on the International Standard Classification of Occupations (see table 2) [18]: managers and professionals; intermediate white-collar workers; service and sales workers; agricultural and fishery workers; skilled manual workers; and unskilled manual workers.

Statistical analyses

To obtain a full picture of inequalities in cancer mortality, we calculate both absolute and relative measures [19], using complete-case analysis. First, directly age-standardized site-specific mortality rates (ASMR) by employment and occupational group are calculated, using the Belgian population at the 2001 census as standard population. Secondly, mortality rate ratios (MRR) are calculated using Poisson regression. We aim to assess the net effect of employment and occupational group on cancer mortality. Therefore, the Poisson models are adjusted for educational attainment and housing conditions. Educational attainment is categorized using the International Standard Classification of Education: lower secondary

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education or less (ISCED 0-2, "low"), higher secondary education (ISCED 3-4, "mid"), and tertiary education (ISCED 5-6, "high"). Housing conditions is the result of a combination of ownership (tenant or owner) and comfort of the house (low-, mid- and high-comfort), resulting in six categories [20]. Sensitivity analyses are additionally conducted without adjustment for education and housing conditions. These results are not shown but are available in the supplementary file (Tables 7 and 8). Important differences between the crude and net model are mentioned in the discussion section. As there is a strong association in Belgium between mortality and region [21], as well as migration history [22], all Poisson models are adjusted for region (Flanders, Wallonia and Brussels) and migrant background (native versus non-native). All analyses are stratified by sex and are performed using STATA 13.1.

RESULTS

Description of the study population

The study population consists of almost 5 million Belgians within the economically active age range (Table 2). Almost four out of five men are employed, whereas in women about one in two has a paid job.

Table 2. Description of the study population

		Men		Women	
ISCO	**Occupational status**	**Population**	**Cancer deaths**	**Population**	**Cancer deaths**
	Disabled	37,286	2,235	26,905	824
	Unemployed and not looking for a job	295,674	21,704	924,226	25,953
	Employed and looking for a job	121,757	4,418	235,766	2,931
	Employed	1,776,668	34,732	1,146,582	11,943
1-2	Managers and professionals	452,268	8,529	339,663	3,512
3-4	Intermediate white-collar workers	432,803	8,114	384,478	3,761
5	Service and sales workers	92,369	1,837	167,625	1,670
6	Agricultural and fishery workers	52,529	1,352	17,303	282
7-8	Skilled manual workers	556,418	10,990	87,631	858
9	Unskilled manual workers	163,433	3,560	147,887	1,848
	Missing	26,848	350	1,995	12

Absolute cancer mortality rates by employment and occupational status

For almost all preventable cancer sites, men belonging to the employed category have systematically the lowest cancer mortality rates (Table 3). Among the employed men, white-collar workers and agricultural and fishery workers have lower cancer mortality rates compared with manual workers (Table 4). These results hold true for all preventable cancer sites, except for prostate cancer and malignant melanoma for which no inequality is observed. For the non-preventable cancer sites, less inequalities are observed, as expected based upon the FCT. For the non-preventable cancer sites, inequalities generally represent differences between employed versus unemployed.

For women, the absolute inequalities are less pronounced. Generally, mortality from preventable cancer sites is largest for women who are unemployed (Table 3). Among the employed women there are no inequalities, except for lung cancer mortality which is somewhat more elevated for service and sales workers and manual workers compared with female managers (Table 4). On the other hand, service and sales workers have a lower breast cancer mortality rate compared with intermediate white-collar workers. Neither do we observe an occupational inequality pattern for mortality from non-preventable cancer sites. The only exception is stomach cancer mortality, which is highest among the unskilled manual workers.

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Table 3. Absolute site-specific cancer mortality rates (ASMR and 95% C.I.) (2001-2011) among the Belgian population within the economically active age range, by employment group in 1991

MEN	Employed	Unemployed and looking for a job	Unemployed and not looking for a job	Disabled
All cancers	256.9 (253.8-260.0)	436.4 (423.0-449.9)	380.2 (368.6-391.9)	484.3 (462.7-506.0)
Preventable cancers				
Head and neck	11.7 (11.2-12.3)	38.6 (34.7-42.4)	24.8 (20.8-28.7)	31.3 (25.0-37.6)
Oesophagus	10.3 (9.7-10.9)	20.9 (18.0-23.7)	12.8 (10.4-15.2)	15.9 (11.9-19.9)
Stomach	8.2 (7.7-8.8)	11.9 (9.7-14.2)	14.5 (12.0-17.0)	17.0 (12.9-21.0)
Colorectal	25.8 (24.8-26.8)	30.4 (26.8-34.0)	34.3 (30.9-37.6)	33.3 (27.9-38.8)
Liver	7.8 (7.2-8.3)	12.5 (10.3-14.7)	10.8 (8.6-13.0)	13.5 (9.8-17.3)
Lung	88.8 (87.0-90.6)	173.1 (164.6-181.7)	148.8 (141.6-156.0)	195.0 (181.6-208.3)
Prostate	17.2 (16.3-18.1)	17.3 (14.4-20.2)	19.1 (17.6-20.6)	27.9 (23.3-32.4)
Bladder	8.1 (7.5-8.7)	14.5 (12.0-17.1)	11.8 (10.3-13.4)	19.5 (15.2-23.8)
Malignant melanoma	3.0 (2.7-3.3)	3.4 (2.2-4.5)	1.9 (1.2-2.6)	3.3 (1.2-5.3)
Non-preventable cancers				
Pancreas	13.5 (12.8-14.3)	18.3 (15.5-21.1)	15.4 (13.3-17.4)	21.3 (16.5-26.1)
Kidney	7.8 (7.2-8.3)	8.1 (6.3-10.0)	9.0 (7.3-10.8)	12.2 (8.8-15.7)
Eye, nervous system	7.3 (6.8-7.8)	6.9 (5.3-8.5)	8.1 (6.2-10.1)	10.4 (7.0-13.9)
Non-Hodgkin	6.2 (5.7-6.7)	8.4 (6.5-10.3)	6.9 (5.5-8.3)	10.1 (6.7-13.5)
Multiple myeloma	3.8 (3.4-4.2)	3.5 (2.3-4.6)	4.0 (3.1-4.9)	4.5 (2.4-6.6)
Leukemia	7.6 (7.0-8.2)	8.6 (6.6-10.6)	10.1 (8.4-11.8)	9.2 (6.4-12.0)
WOMEN	**Employed**	**Unemployed and looking for a job**	**Unemployed and not looking for a job**	**Disabled**
Cancer deaths	164.7 (160.0-169.4)	200.2 (181.6-218.9)	187.5 (184.8-190.3)	312.4 (286.7-338.1)
Preventable cancers				
Oesophagus	3.3 (2.5-4.0)	3.0 (2.2-3.9)	2.8 (2.5-3.1)	4.7 (2.0-7.3)
Colorectal	15.4 (14.0-16.8)	16.3 (11.6-20.9)	18.5 (17.7-19.2)	35.7 (26.6-44.7)
Lung	23.9 (22.2-25.7)	40.4 (31.6-49.3)	28.7 (27.6-29.9)	51.5 (41.1-61.9)
Breast	41.0 (38.8-43.1)	40.7 (33.4-47.9)	42.4 (41.0-43.8)	70.8 (58.3-83.3)
Cervix	2.8 (2.2-3.3)	7.3 (2.9-11.6)	3.9 (3.4-4.4)	3.8 (0.7-6.9)
Uterus	5.6 (4.6-6.6)	5.0 (3.9-6.1)	6.1 (5.6-6.5)	7.4 (3.9-10.9)
Bladder	1.6 (1.2-2.1)	2.9 (0.0-6.0)	2.5 (2.2-2.8)	7.6 (3.4-11.7)
Malignant melanoma	2.5 (2.0-2.9)	3.8 (0.7-6.9)	2.3 (2.0-2.6)	1.9 (0.3-3.9)
Non-preventable cancers				
Stomach	3.2 (2.6-3.9)	4.4 (1.3-7.5)	4.4 (4.0-4.8)	9.8 (4.7-14.8)
Liver	2.9 (2.3-3.5)	5.6 (1.3-9.9)	4.6 (4.2-5.0)	6.1 (2.7-9.5)
Pancreas	10.4 (9.0-11.7)	8.3 (5.0-11.5)	10.9 (10.3-11.5)	14.5 (9.1-19.9)
Ovary	13.4 (12.0-14.7)	9.0 (7.6-10.5)	12.4 (11.7-13.1)	13.2 (8.1-18.3)
Kidney	2.8 (2.2-3.4)	5.8 (1.4-10.1)	4.3 (3.9-4.7)	6.8 (3.9-9.7)
Eye, nervous system	5.3 (4.5-6.1)	5.4 (2.3-8.5)	5.7 (5.2-6.3)	11.1 (6.2-16.0)
Non-Hodgkin	3.9 (3.1-4.7)	4.6 (1.5-7.8)	4.6 (4.2-5.0)	7.2 (2.7-11.8)
Multiple myeloma	2.7 (2.0-3.4)	3.2 (0.1-6.3)	3.3 (2.9-3.6)	2.1 (0.2-4.0)
Leukemia	5.0 (4.1-5.9)	2.6 (1.8-3.4)	5.3 (4.9-5.7)	8.7 (3.9-13.6)

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Table 4. Absolute site-specific cancer mortality rates (ASMR and 95% C.I.) (2001-2011) among the Belgian employed population, by occupational group in 1991

MEN	Managers and professionals	Intermediate white-collar	Service and sales workers	Agricultural and fishery workers	Skilled manual workers	Unskilled manual workers
All cancers	163.3 (159.8-166.9)	190.0 (185.9-194.1)	232.3 (221.6-242.9)	177.6 (166.5-188.7)	228.4 (224.0-232.8)	246.3 (238.1-254.4)
Preventable cancers						
Head and neck	8.2 (7.4-9.0)	10.1 (9.2-11.0)	14.7 (12.1-17.3)	9.8 (6.9-12.8)	12.4 (11.4-13.3)	17.0 (14.9-19.1)
Oesophagus	7.6 (6.9-8.4)	8.5 (7.6-9.3)	9.3 (7.2-11.4)	6.4 (4.2-8.7)	9.4 (8.5-10.3)	10.2 (8.5-11.8)
Stomach	5.2 (4.6-5.8)	6.2 (5.4-6.9)	5.4 (3.8-7.1)	6.1 (4.1-8.1)	7.9 (7.1-8.7)	8.3 (6.8-9.9)
Colorectal	17.5 (16.4-18.6)	19.0 (17.7-20.3)	21.2 (17.9-24.4)	13.6 (10.6-16.5)	20.5 (19.1-21.8)	20.3 (17.9-22.7)
Liver	6.3 (5.6-7.0)	6.0 (5.2-6.7)	6.7 (4.9-8.5)	2.0 (0.8-3.2)	5.5 (4.8-6.2)	7.0 (5.7-8.4)
Lung	48.0 (46.1-49.9)	62.8 (60.5-65.2)	84.8 (78.4-91.3)	65.1 (58.4-71.9)	91.1 (88.3-93.8)	97.1 (91.9-102.2)
Prostate	9.6 (8.8-10.4)	10.2 (9.2-11.2)	11.5 (9.0-13.9)	9.5 (7.3-11.7)	10.6 (9.6-11.7)	11.4 (9.5-13.2)
Bladder	4.7 (4.1-5.3)	5.8 (5.1-6.6)	7.0 (5.1-8.9)	4.0 (2.4-5.5)	6.0 (5.3-6.7)	8.2 (6.6-9.7)
Malignant melanoma	2.9 (2.4-3.4)	2.7 (2.2-3.2)	3.8 (2.4-5.1)	3.0 (1.4-4.6)	2.4 (2.0-2.8)	2.2 (1.4-2.9)
Non-preventable cancers						
Pancreas	10.7 (9.8-11.6)	10.2 (9.2-11.2)	11.6 (9.2-14.0)	10.3 (7.5-13.0)	10.1 (9.1-11.0)	11.0 (9.3-12.8)
Kidney	5.5 (4.9-6.2)	6.2 (5.5-7.0)	6.0 (4.3-7.7)	5.4 (3.6-7.3)	6.0 (5.3-6.7)	5.4 (4.2-6.6)
Eye, nervous system	6.5 (5.8-7.3)	6.8 (6.0-7.5)	6.9 (5.1-8.7)	5.3 (3.3-7.3)	6.2 (5.5-6.9)	6.0 (4.7-7.2)
Non-Hodgkin	4.6 (4.0-5.1)	4.5 (3.9-5.1)	5.3 (3.7-6.9)	6.7 (4.4-9.0)	4.8 (4.2-5.5)	3.5 (2.5-4.5)
Multiple myeloma	2.5 (2.1-3.0)	3.0 (2.5-3.5)	2.5 (1.3-3.6)	3.4 (1.9-4.9)	2.6 (2.1-3.0)	3.1 (2.2-4.0)
Leukemia	4.9 (4.3-5.5)	5.2 (4.5-5.9)	6.7 (4.9-8.5)	6.0 (4.1-7.9)	5.5 (4.8-6.2)	5.7 (4.5-7.0)

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Table 4. Continued

WOMEN	Managers and professionals	Intermediate white-collar	Service and sales workers	Agricultural and fishery workers	Skilled manual workers	Unskilled manual workers
Cancer deaths	98.2 (95.0-101.5)	106.1 (102.7-109.6)	101.9 (97.0-106.8)	92.9 (79.0-106.8)	107.7 (100.2-115.1)	111.1 (106.0-116.2)
Preventable cancers						
Oesophagus	1.3 (0.9-1.6)	1.7 (1.3-2.2)	2.2 (1.4-2.9)	1.5 (0.0-3.2)	1.2 (0.4-2.0)	1.8 (1.1-2.4)
Colorectal	8.3 (7.3-9.2)	9.9 (8.8-11.0)	8.6 (7.2-10.0)	5.6 (2.5-8.7)	11.4 (9.0-13.8)	8.3 (6.9-9.6)
Lung	13.5 (12.3-14.7)	16.5 (15.2-17.8)	17.9 (15.9-20.0)	8.6 (4.5-12.8)	17.2 (14.3-20.1)	22.2 (19.9-24.5)
Breast	30.3 (28.5-32.1)	32.1 (30.2-33.9)	26.6 (24.1-29.1)	28.9 (20.6-37.3)	30.1 (26.2-33.9)	27.7 (25.1-30.3)
Cervix	1.9 (1.4-2.3)	1.8 (1.4-2.3)	2.6 (1.8-3.3)	1.4 (0.0-3.1)	1.9 (0.9-2.8)	3.0 (2.1-3.9)
Uterus	2.4 (1.9-2.9)	2.6 (2.0-3.1)	3.3 (2.4-4.2)	1.6 (0.4-2.8)	3.7 (2.1-5.2)	2.0 (1.4-2.7)
Bladder	0.8 (0.5-1.1)	0.8 (0.5-1.1)	1.1 (0.6-1.6)	0.5 (0.0-1.2)	0.9 (0.2-1.7)	1.0 (0.5-1.5)
Malignant melanoma	1.8 (1.4-2.3)	2.1 (1.6-2.6)	1.7 (1.0-2.3)	3.0 (0.2-5.7)	2.3 (1.3-3.4)	2.3 (1.5-3.0)
Non-preventable cancers						
Stomach	1.6 (1.2-2.0)	1.8 (1.3-2.2)	1.8 (1.2-2.5)	5.4 (1.8-9.0)	2.2 (1.1-3.3)	3.1 (2.3-4.0)
Liver	1.4 (1.0-1.8)	1.5 (1.1-1.9)	1.7 (1.1-2.3)	1.4 (0.0-2.9)	1.5 (0.6-2.4)	2.1 (1.4-2.8)
Pancreas	5.5 (4.7-6.3)	5.2 (4.4-5.9)	5.5 (4.4-6.7)	3.1 (1.5-4.8)	4.8 (3.2-6.4)	5.6 (4.5-6.8)
Ovary	7.4 (6.5-8.3)	7.2 (6.3-8.1)	7.0 (5.7-8.2)	10.4 (6.0-14.9)	8.5 (6.4-10.6)	8.3 (6.9-9.7)
Kidney	1.9 (1.4-2.3)	1.5 (1.1-2.0)	1.8 (1.2-2.5)	1.7 (0.0-3.4)	1.6 (0.7-2.5)	1.5 (1.0-2.1)
Eye, nervous system	4.1 (3.4-4.8)	3.5 (2.9-4.1)	3.6 (2.7-4.5)	4.2 (0.8-7.5)	3.3 (2.1-4.5)	4.1 (3.2-5.1)
Non-Hodgkin	1.8 (1.3-2.2)	2.2 (1.7-2.7)	1.9 (1.3-2.6)	1.7 (0.0-3.5)	2.8 (1.6-4.0)	2.0 (1.3-2.7)
Multiple myeloma	1.2 (0.8-1.5)	1.3 (0.9-1.7)	1.2 (0.7-1.7)	2.6 (0.0-5.5)	1.0 (0.2-1.7)	1.2 (0.6-1.7)
Leukemia	2.4 (1.9-2.9)	2.6 (2.0-3.1)	2.6 (1.8-3.4)	2.9 (0.4-5.5)	3.3 (1.9-4.8)	2.8 (2.0-3.7)

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Table 5. Net relative site-specific cancer mortality inequality (MRR and 95% C.I.) (2001-2011) among the Belgian population within the economically active age range, by employment group in 1991

MEN	Employed	Unemployed and looking for a job		Unemployed and not looking for a job		Disabled	
All cancers	1.00	1.60	1.55,1.65	2.74	2.69,2.80	2.28	2.19,2.37
Preventable cancers							
Head and neck	1.00	2.33	2.10,2.59	2.73	2.46,3.02	2.18	1.80,2.65
Oesophagus	1.00	2.09	1.83,2.38	2.36	2.12,2.62	1.98	1.59,2.48
Stomach	1.00	1.35	1.13,1.61	2.97	2.68,3.30	2.65	2.15,3.28
Colorectal	1.00	1.26	1.14,1.41	2.61	2.45,2.77	1.71	1.48,1.99
Liver	1.00	1.49	1.25,1.76	2.31	2.06,2.60	2.29	1.82,2.88
Lung	1.00	1.71	1.63,1.79	2.86	2.77,2.95	2.52	2.37,2.69
Prostate	1.00	1.17	1.01,1.35	2.78	2.59,2.99	2.30	1.96,2.70
Bladder	1.00	1.91	1.62,2.25	3.37	3.05,3.73	2.65	2.13,3.29
Malignant melanoma	1.00	1.30	0.97,1.73	1.90	1.57,2.31	1.05	0.59,1.88
Non-preventable cancers							
Pancreas	1.00	1.38	1.21,1.58	2.44	2.24,2.66	1.85	1.53,2.25
Kidney	1.00	1.18	0.97,1.45	2.39	2.14,2.68	2.52	2.01,3.16
Eye, nervous system	1.00	0.94	0.75,1.17	2.14	1.88,2.44	2.15	1.64,2.82
Non-Hodgkin	1.00	1.35	1.09,1.66	2.42	2.13,2.75	1.79	1.33,2.43
Multiple myeloma	1.00	1.25	0.93,1.68	2.86	2.46,3.32	1.48	0.97,2.25
Leukemia	1.00	1.05	0.84,1.31	2.73	2.44,3.06	1.72	1.30,2.28
WOMEN	**Employed**	**Unemployed and looking for a job**		**Unemployed and not looking for a job**		**Disabled**	
Cancer deaths	1.00	1.11	1.07,1.15	1.74	1.71,1.78	1.96	1.83,2.09
Preventable cancers							
Oesophagus	1.00	1.35	1.04,1.75	1.67	1.40,1.99	1.94	1.15,3.26
Colorectal	1.00	1.09	0.97,1.23	1.79	1.68,1.92	2.23	1.83,2.73
Lung	1.00	1.19	1.10,1.29	1.61	1.53,1.70	1.82	1.54,2.14
Breast	1.00	1.02	0.95,1.09	1.64	1.57,1.71	1.93	1.68,2.22
Cervix	1.00	1.78	1.45,2.18	1.85	1.57,2.19	0.90	0.42,1.91
Uterus	1.00	1.36	1.11,1.67	2.12	1.86,2.40	1.83	1.22,2.75
Bladder	1.00	1.07	0.73,1.56	1.99	1.63,2.43	3.20	1.92,5.34
Malignant melanoma	1.00	1.02	0.79,1.32	1.35	1.14,1.59	1.09	0.54,2.21
Non-preventable cancers							
Stomach	1.00	1.03	0.81,1.31	1.70	1.48,1.96	2.26	1.50,3.40
Liver	1.00	1.10	0.84,1.44	2.31	1.99,2.68	1.63	0.98,2.70
Pancreas	1.00	0.94	0.80,1.11	1.76	1.61,1.92	1.65	1.23,2.22
Ovary	1.00	0.99	0.86,1.14	1.56	1.44,1.69	1.13	0.82,1.56
Kidney	1.00	1.21	0.93,1.57	2.04	1.76,2.35	3.33	2.28,4.87
Eye, nervous system	1.00	0.79	0.64,0.98	1.61	1.43,1.80	1.39	0.89,2.18
Non-Hodgkin	1.00	0.99	0.76,1.29	1.96	1.70,2.25	1.54	0.95,2.52
Multiple myeloma	1.00	0.93	0.65,1.34	2.33	1.96,2.77	1.32	0.65,2.69
Leukemia	1.00	0.75	0.57,0.97	1.66	1.46,1.88	1.35	0.85,2.15

Reference category is employed
All analyses are adjusted for current age, region, migrant background, educational attainment and housing conditions

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Table 6. Net relative site-specific cancer mortality inequality (MRR and 95% C.I.) (2001-2011) among the Belgian employed population, by occupational group in 1991

MEN	Managers and professionals	Intermediate white-collar		Service and sales workers		Agricultural and fishery workers		Skilled manual workers		Unskilled manual workers	
All cancers	1.00	0.93	0.91,0.96	0.95	0.91,0.99	0.93	0.88,0.97	0.90	0.87,0.93	0.94	0.90,0.97
Preventable cancers											
Head and neck	1.00	0.92	0.82,1.04	1.03	0.86,1.23	0.67	0.52,0.88	0.83	0.73,0.95	1.13	0.98,1.32
Oesophagus	1.00	0.90	0.80,1.01	0.84	0.68,1.04	0.66	0.50,0.87	0.83	0.73,0.95	0.87	0.73,1.04
Stomach	1.00	0.98	0.85,1.13	0.88	0.68,1.14	0.99	0.74,1.33	0.99	0.84,1.16	1.03	0.84,1.27
Colorectal	1.00	0.89	0.82,0.97	0.80	0.69,0.93	0.80	0.68,0.94	0.79	0.72,0.86	0.83	0.73,0.94
Liver	1.00	0.73	0.63,0.84	0.54	0.41,0.72	0.24	0.15,0.39	0.56	0.48,0.65	0.64	0.52,0.79
Lung	1.00	0.97	0.93,1.02	1.04	0.97,1.12	0.98	0.90,1.07	1.07	1.02,1.12	1.05	0.99,1.12
Prostate	1.00	0.87	0.78,0.97	0.83	0.68,1.01	1.11	0.92,1.34	0.75	0.67,0.85	0.86	0.73,1.01
Bladder	1.00	0.93	0.79,1.08	0.94	0.72,1.22	0.74	0.54,1.01	0.85	0.72,1.00	1.08	0.88,1.34
Malignant melanoma	1.00	0.86	0.70,1.04	1.11	0.81,1.53	1.11	0.76,1.62	0.53	0.42,0.66	0.62	0.45,0.84
Non-preventable cancers											
Pancreas	1.00	0.88	0.79,0.98	0.84	0.69,1.01	0.94	0.76,1.15	0.74	0.66,0.83	0.78	0.67,0.92
Kidney	1.00	0.94	0.82,1.08	0.85	0.66,1.10	0.85	0.64,1.14	0.77	0.66,0.90	0.64	0.51,0.81
Eye, nervous system	1.00	0.93	0.81,1.06	0.87	0.69,1.11	0.93	0.70,1.23	0.70	0.61,0.82	0.70	0.56,0.87
Non-Hodgkin	1.00	0.85	0.73,1.00	1.00	0.76,1.31	1.32	0.99,1.76	0.83	0.69,0.99	0.72	0.55,0.93
Multiple myeloma	1.00	1.09	0.90,1.34	0.69	0.44,1.07	1.55	1.09,2.22	0.82	0.65,1.04	0.90	0.65,1.25
Leukemia	1.00	0.95	0.81,1.11	1.13	0.87,1.47	1.33	1.01,1.74	0.90	0.76,1.07	0.95	0.75,1.20

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Table 6. Continued

WOMEN	Managers and professionals	Intermediate white-collar		Service and sales workers		Agricultural and fishery workers		Skilled manual workers		Unskilled manual workers	
Cancer deaths	1.00	0.89	0.86,0.93	0.79	0.75,0.83	0.91	0.82,1.02	0.77	0.72,0.82	0.83	0.79,0.88
Preventable cancers											
Oesophagus	1.00	0.86	0.60,1.22	1.02	0.66,1.59	0.94	0.39,2.25	0.56	0.29,1.07	0.95	0.60,1.52
Colorectal	1.00	1.00	0.88,1.15	0.84	0.70,1.01	0.66	0.43,1.01	1.04	0.85,1.29	0.86	0.71,1.03
Lung	1.00	0.89	0.80,0.99	0.82	0.72,0.94	0.48	0.33,0.70	0.78	0.66,0.92	0.86	0.75,0.98
Breast	1.00	0.93	0.86,1.00	0.74	0.67,0.82	1.03	0.84,1.27	0.75	0.66,0.85	0.75	0.67,0.84
Cervix	1.00	0.79	0.57,1.08	0.78	0.53,1.15	0.44	0.14,1.41	0.54	0.33,0.88	0.80	0.55,1.18
Uterus	1.00	0.91	0.70,1.19	1.07	0.78,1.47	0.68	0.32,1.42	0.91	0.59,1.42	0.70	0.48,1.02
Bladder	1.00	0.93	0.59,1.47	1.68	0.95,2.98	1.69	0.57,4.97	1.61	0.81,3.22	1.48	0.78,2.81
Malignant melanoma	1.00	1.07	0.81,1.40	0.68	0.45,1.03	0.76	0.31,1.88	0.95	0.61,1.47	1.03	0.72,1.49
Non-preventable cancers											
Stomach	1.00	1.03	0.76,1.41	0.90	0.61,1.35	1.68	0.87,3.21	0.87	0.52,1.43	1.67	1.16,2.40
Liver	1.00	0.78	0.56,1.10	0.64	0.41,0.99	0.27	0.06,1.14	0.71	0.40,1.24	1.07	0.72,1.59
Pancreas	1.00	0.80	0.67,0.95	0.76	0.61,0.96	0.82	0.52,1.31	0.72	0.53,0.98	0.89	0.70,1.12
Ovary	1.00	0.76	0.65,0.88	0.79	0.64,0.96	1.63	1.20,2.21	0.82	0.64,1.04	0.79	0.64,0.97
Kidney	1.00	0.54	0.39,0.74	0.70	0.47,1.03	1.04	0.52,2.09	0.59	0.36,0.98	0.62	0.41,0.94
Eye, nervous system	1.00	0.73	0.59,0.90	0.80	0.62,1.05	1.16	0.69,1.95	0.71	0.50,1.00	0.72	0.53,0.97
Non-Hodgkin	1.00	1.01	0.75,1.35	0.78	0.53,1.15	1.33	0.69,2.59	1.09	0.69,1.72	0.82	0.56,1.21
Multiple myeloma	1.00	0.98	0.70,1.38	0.91	0.57,1.45	0.77	0.27,2.17	0.71	0.35,1.43	0.80	0.49,1.30
Leukemia	1.00	0.87	0.68,1.12	0.75	0.53,1.07	0.89	0.47,1.69	0.77	0.51,1.18	0.89	0.64,1.24

Reference category is managers and professionals
All analyses are adjusted for current age, region, migrant background, educational attainment and housing conditions

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Relative cancer mortality inequality by employment and occupational status

In this paragraph, we present the results of the net relative models, adjusted for education and housing conditions. Unemployed men and women have higher site-specific cancer mortality rates compared with employed people (Table 5). This holds true for preventable and non-preventable cancers and are especially observed among the unemployed that are not looking for a job. To illustrate this with an example: unemployed men that are not looking for a job have a three times higher chance of dying from bladder cancer (MRR: 3.37; 95% C.I.: 3.05-3.73) compared with employed men. For most cancer sites (mainly the preventable cancers) particularly unemployed men and women that are either not looking for a job or disabled have consistently higher cancer mortality rates compared with employed men and women.

Within the employed population inequalities by occupation are also observed although more in men than in women (Table 6). In men, managers appear to have higher colorectal and liver cancer mortality rates compared with men in other occupations. Furthermore, lower mortality rates in favour of manual workers are observed for several non-preventable cancer sites, amongst others cancer of the pancreas and kidney. Compared with male managers skilled manual workers have a 7% higher lung cancer mortality rate. Another interesting observation is the mortality pattern of the agricultural and fishery workers. Compared with managers, they tend to die less from preventable cancers such as head and neck and oesophageal cancers. Their liver cancer mortality rate is even 76% lower compared with managers (MRR: 0.24; 95% C.I.: 0.15-0.39). In contrast, agricultural and fishery workers show higher mortality from some non-preventable cancer sites such as leukaemia and multiple myeloma. Female manual workers and service and sales workers have about 25% lower breast cancer mortality rates compared with female managers.

DISCUSSION AND CONCLUSION

Methodological issues

The findings are based upon a high-quality and exhaustive dataset including the total Belgian population within the economically active age range. A numerator-denominator bias was eliminated through record linkage between census and register data. This dataset provides very rich information on SD as well as SE variables and mortality for a follow-up period of 11 years. This enables us to give precise estimates of site-specific cancer mortality inequalities at the individual level. However, these register data do not contain information on incidence or survival, nor on health behaviours, health care use, or important aspects of the job (e.g. occupational exposures, psychosocial factors), which are all likely to be associated with cancer outcomes [23]. Therefore it is difficult to make solid conclusions on the relative importance of all these factors to explain the observed SE inequalities in cancer mortality [23,24].

We included the total Belgian population that belonged to the economically active age group (25-65 years) at the census of 1991, independently of their actual occupational status. We decided so because we were interested in the association between cancer mortality and both employment and occupational group. By doing so, we avoided a selection effect due to including only the healthy workers [6,25–28]. Our results indicate the importance of this issue, showing highest (site-specific) cancer mortality among the unemployed groups. Nevertheless, we cannot fully exclude a selection effect among the employed population because we can assume that unhealthy persons are less frequently employed in physically demanding jobs [26,27]. A healthy worker effect might then be more likely in the groups of manual workers, which could partly explain some of the observed mortality patterns in favour of manual workers. On the other hand, the white-collar workers may have less physically demanding jobs, which can counter this effect. Occupational information was derived from the census of 1991, which is the most recent source of detailed information since the census of 2001 does not contain detailed occupational information. Because of the lag time between some (occupational) exposures and cancer mortality, we do not consider this as a problem [29]. Due to the cross-sectional nature of this information, the occupation is not necessarily the longest job respondents were involved in, nor do we have information on the duration of this occupation [25]. However, occupation was

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grouped into broad groups, which leads us to assume that the bias due to transitions between occupational categories will be rather small [30].

We decided not to use the robust distinction between manual versus non-manual workers, nor did we focus on one specific cancer site in relation to one or more job exposures. These choices have been made in order to gain insights into the overall association between occupational status and cancer mortality [26]. Many studies assessing SE inequalities in cancer mortality use only one SE indicator at a time although the importance of including multiple indicators has already been pointed out [9,11,12] because different SEP indicators tap into different pathways [8–10]. Housing conditions are related to material and financial resources, and therefore to healthcare utilisation [31]. Education captures the human capital acquired early in life and may be related to the ability to adapt health education messages, and hence to health behaviours [6]. Occupational status on the other hand reflects the ability to realize this human capital in the labour market, and is rather a reflection of one's social class at older ages. Employment as well as occupation is likely to (partially) capture material resources, access to health care as well as social networks and work-related factors such as stress, autonomy and occupational hazards. Hence, we need to analyse all aspects of SEP in relation to health outcomes, although these indicators are closely related. In this paper, we focus on the net effect of occupational status, thereby adjusting for educational attainment and housing conditions. The results indicate an association between occupational status and site-specific cancer mortality, independently of education and housing conditions.

Finally, we classified the cancer sites by their level of preventability (see Methods). We acknowledge that this classification does not exclude the fact that some "non-preventable" cancers are also related to behavioural change and/or medical interventions, nor does it eliminate some possible overlap between these two criteria of preventability. However, to enhance the comparability with other studies, we decided to adopt this often-used classification.

Theoretical considerations on the main findings

This study reveals inequalities in site-specific cancer mortality by employment and occupational groups. Generally SE inequalities are less pronounced in women compared with men, which is consistent with the literature [7,23,28]. The unemployed group (and especially those not looking for a job) shows both for men and women higher cancer mortality rates compared with the employed, which is in line with previous studies in France and the UK [23,32]. Possible explanations are financial insecurity, which is related to a lower use of health care services, and an unhealthy lifestyle [32]. Some studies suggest that part of this association between unemployment and health might be due to health selection [23], although others observed an ongoing effect after adjustment for pre-existing morbidity [32]. However, it is very likely that for the unemployed that are not looking for a job, as well as for the disabled group, health selection will be at play.

Also within the employed group, inequalities by occupational group are observed. In men these findings are in line with the FCT which expects larger inequalities for more preventable cancer sites [3,5]. The absolute results show that male manual workers have the highest site-specific cancer mortality rates whereas white-collar workers and agricultural and fishery workers have the lowest cancer mortality rates. This discrepancy between manual and non-manual workers is in line with previous findings in Europe [6,33]. These absolute inequalities are manifest for all preventable cancer sites (except for non-malignant melanoma and prostate cancer), with alcohol- and smoking-related cancers (e.g. cancers of the lung, head and neck and bladder) being the main contributors to these inequalities, as reported in previous studies [25,28,30,33,34]. The excess mortality for cancers of the head and neck and lung are also observed for male service and sales workers, which can be explained by the higher likelihood of occupational exposure to tobacco and alcohol in bars and restaurants [27]. Another interesting finding is the favourable cancer mortality pattern for farmers, which might be related to their healthy life style with less tobacco and alcohol use and more physical activity [35,36].

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According to the FCT, the availability of valuable resources such as knowledge, money, power, prestige and beneficial social connections are the social causes of health inequalities [2]. When there is sound knowledge of the causes and cures of cancers, those in high SEP contexts, with greater access to resources, will disproportionally benefit from this knowledge. Several mechanisms have been suggested to explain this association, such as a differential acquisition of knowledge on health-damaging behaviours (e.g. smoking, bad diet, alcohol intake or a lack of exercise) [6,7,10,23,26,37]. Also material factors are important: having financial difficulties might be related to poor living conditions [7,23,30] or the inability to optimise the use of health services [10,33,37]. Both access to and quality of health care are crucial for health outcomes in all stages, from prevention (e.g. through cancer screening) to treatment. Finally, the social aspect of SEP is associated with health, for example stress-related factors or the level of social prestige [25]. Since we cannot adjust for health behaviours or health care use, it remains difficult to decide on the extent of inequalities due to each of these mechanisms [26]. Yet, our findings showed that the inequalities were especially large for the preventable cancer sites related to health behaviours such as smoking and alcohol use. Previous studies mediating the observed gradients for smoking reported an attenuated but still significant relation between SEP and mortality [7,24,30], which assumes that there might be other factors at play as well. Sensitivity analyses not adjusting for education and housing conditions showed both for men and women lowest lung cancer mortality among the managers compared with all other occupational groups (supplementary file, table 8). However, in the models adjusted for education and housing conditions (presented in table 6), the association reversed for women, whereas for men lung cancer mortality only remains somewhat higher for male skilled manual workers, which could be related to occupational exposures. In contrary, in the adjusted model higher breast cancer mortality rates were observed in female managers compared with all other occupations except sales and service workers. This can be explained by differences in reproductive behaviour, with less children and a later age at first birth for the white-collar occupations [24,28]. In the net model, male managers had higher colorectal and liver cancer mortality compared with all other occupations. Yet, in the unadjusted model, the association between occupation and colorectal cancer mortality disappeared (supplementary file, table 8). Moreover, compared with the white-collar occupations, manual workers do have lower mortality for several other cancer sites (e.g. malignant melanoma and kidney). These results are counterintuitive, suggesting that there are other factors at play, such as an unhealthy and sedentary lifestyle of managers [38,39].

We can assume that the results of the net model are more likely to be due to differences related to the job itself. Yet, a healthy lifestyle may be induced by the social environment (e.g. the colleagues at work), and therefore might not be excluded as a potential mechanism [6]. Specific occupational exposures and hazards may explain part of the association between occupational status and health [7,10,23]. Another important aspect of work related to health is the psychosocial aspect of the job, such as the sense of control and autonomy, the level of job strain, or long working hours [7,23,25,30,40]. This could be an explanation for the excessive colorectal cancer mortality among male managers. Colorectal cancer is associated with perceived stress, and could therefore be related to the long working hours and work strain as perceived by managers [38,40].

Implications and conclusions

This paper highlights important SE inequalities in site-specific cancer mortality by employment and occupational groups. Being unemployed, and among the employed, being employed as a manual worker or service and sales worker is associated with higher overall and site-specific cancer mortality. These unfavourable mortality patterns among the unemployed and manual and service and sales workers were especially observed for the more preventable cancers, as we assumed based upon the FCT. These occupational inequalities change when other SEP indicators are adjusted for. Multiple SEP indicators should be taken into account when studying SE inequalities in health [9,11,12] because these allow for different causal pathways [8–10]. Yet,

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it is difficult to identify to what extent the potential explanatory factors attribute to these inequalities because we do not dispose of data on incidence or survival, nor on data on risk factors, health care use, or job characteristics. Future studies having access to these kind of data could help to unravel the complex interplay between incidence, survival and mortality, and to clarify at which steps the social differences operate [23,24].

This study can be helpful in providing evidence for policy makers in order to reduce SE inequalities in cancer mortality [37]. Our results prove that there is still a long way to go. We observed for example that the unemployed groups are at a much higher risk of dying from cancer compared with the employed population. Ensuring financial security for the unemployed is a key issue in this regard [32]. Future research could also study other working regimes, e.g. temporary or part-time employment, and their relation to health. Finally, there could be an important role for the general practitioner to make sure that the unemployed are getting the health care they need [32]. Also for the high-risks jobs, regular health checks at the work floor are needed in order to detect cancers at an early stage.

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Competing interests

We have read and understood the BMJ policy on the declaration of interests and declare that we have no competing interests.

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Authors' contributions

KV designed and conducted the study and wrote the first draft of the manuscript. LVdB, HV, PH and SG helped with the interpretation of the results and critically revised this first draft. KV, LvDB, HV, PH and SG approved the final version of the manuscript.

Data sharing statement

Analyses are based on administrative data from the Belgian Census, the Belgian mortality register and death certificates provided by Statistics Belgium. The availability of the data is restricted. Permission for analyses must be granted after verification of the research goals by the Belgian Commission for the protection of privacy.

Ethical approval

This research as well as the data adhere to the ethical code of scientific research in Belgium, see: http://www.belspo.be/belspo/organisation/publ/pub_ostc/Eth_code/ethcode_nl.pdf.
All authors have signed the ethical code.

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Table 7. Unadjusted relative site-specific cancer mortality inequality (MRR and 95% C.I.) (2001-2011) among the Belgian population within the economically active age range, by employment group in 1991

MEN	Employed	Unemployed and looking for a job		Unemployed and not looking for a job		Disabled	
All cancers	1.00	1.96	1.92,2.01	3.07	3.02,3.12	2.69	2.60,2.78
Preventable cancers							
Head and neck	1.00	3.65	3.35,3.97	3.39	3.11,3.70	3.30	2.84,3.84
Oesophagus	1.00	2.41	2.16,2.69	2.61	2.38,2.87	2.11	1.74,2.55
Stomach	1.00	1.53	1.32,1.78	3.24	2.96,3.55	3.12	2.63,3.71
Colorectal	1.00	1.45	1.33,1.59	2.79	2.64,2.94	1.89	1.67,2.13
Liver	1.00	1.74	1.51,2.00	2.38	2.15,2.64	2.26	1.85,2.76
Lung	1.00	2.25	2.16,2.34	3.45	3.35,3.55	3.20	3.04,3.37
Prostate	1.00	1.27	1.13,1.44	2.82	2.65,3.00	2.64	2.32,3.00
Bladder	1.00	2.14	1.86,2.45	3.46	3.17,3.77	3.53	2.99,4.15
Malignant melanoma	1.00	1.29	0.99,1.66	1.77	1.49,2.10	1.32	0.86,2.04
Non-preventable cancers							
Pancreas	1.00	1.49	1.33,1.68	2.61	2.43,2.82	2.03	1.73,2.39
Kidney	1.00	1.26	1.06,1.50	2.45	2.21,2.71	2.45	2.01,2.99
Eye, nervous system	1.00	1.00	0.83,1.20	2.15	1.91,2.41	1.96	1.55,2.49
Non-Hodgkin	1.00	1.56	1.31,1.85	2.48	2.21,2.77	2.09	1.64,2.66
Multiple myeloma	1.00	1.22	0.95,1.57	2.76	2.42,3.15	1.79	1.30,2.46
Leukemia	1.00	1.19	1.00,1.43	2.80	2.54,3.09	1.88	1.50,2.36

WOMEN	Employed	Unemployed and looking for a job		Unemployed and not looking for a job		Disabled	
Cancer deaths	1.00	1.25	1.21,1.28	1.91	1.88,1.95	2.29	2.17,2.42
Preventable cancers							
Oesophagus	1.00	1.69	1.36,2.09	1.74	1.49,2.02	2.18	1.42,3.35
Colorectal	1.00	1.19	1.07,1.32	1.93	1.82,2.05	2.52	2.14,2.98
Lung	1.00	1.52	1.41,1.63	1.92	1.83,2.01	2.43	2.12,2.78
Breast	1.00	1.04	0.98,1.11	1.72	1.65,1.78	1.97	1.75,2.21
Cervix	1.00	2.12	1.78,2.54	2.31	2.00,2.67	1.64	0.96,2.81
Uterus	1.00	1.61	1.35,1.93	2.27	2.02,2.54	2.28	1.64,3.18
Bladder	1.00	1.12	0.80,1.57	2.32	1.94,2.77	4.94	3.40,7.18
Malignant melanoma	1.00	1.11	0.88,1.41	1.38	1.20,1.60	1.23	0.69,2.20
Non-preventable cancers							
Stomach	1.00	1.18	0.95,1.48	2.09	1.84,2.37	2.90	2.07,4.08
Liver	1.00	1.25	0.98,1.59	2.65	2.32,3.04	2.83	1.97,4.06
Pancreas	1.00	1.01	0.88,1.17	1.80	1.67,1.94	1.86	1.47,2.36
Ovary	1.00	1.03	0.91,1.16	1.63	1.52,1.75	1.36	1.05,1.75
Kidney	1.00	1.21	0.94,1.54	2.31	2.02,2.64	3.38	2.42,4.73
Eye, nervous system	1.00	0.88	0.73,1.06	1.72	1.55,1.90	2.26	1.67,3.07
Non-Hodgkin	1.00	1.14	0.90,1.44	2.18	1.92,2.47	1.84	1.23,2.77
Multiple myeloma	1.00	0.91	0.65,1.25	2.33	2.00,2.71	0.99	0.50,1.93
Leukemia	1.00	0.76	0.60,0.96	1.82	1.63,2.04	1.72	1.20,2.47

Reference category is employed
All analyses are adjusted for current age, region and migrant background

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Table 8. Relative site-specific cancer mortality inequality (MRR and 95% C.I.) (2001-2011) among the Belgian employed population, by occupational group in 1991

MEN	Managers and professionals	Intermediate white-collar		Service and sales workers		Agricultural and fishery workers		Skilled manual workers		Unskilled manual workers	
All cancers	1.00	1.08	1.05,1.10	1.29	1.24,1.34	1.25	1.20,1.31	1.27	1.24,1.30	1.40	1.35,1.44
Preventable cancers											
Head and neck	1.00	1.19	1.07,1.32	1.72	1.48,2.01	1.16	0.92,1.46	1.48	1.34,1.63	2.04	1.80,2.30
Oesophagus	1.00	1.00	0.90,1.12	1.06	0.87,1.28	0.89	0.70,1.13	1.13	1.02,1.26	1.25	1.08,1.44
Stomach	1.00	1.08	0.95,1.22	1.00	0.79,1.27	1.30	1.02,1.66	1.28	1.14,1.44	1.39	1.18,1.64
Colorectal	1.00	1.00	0.93,1.07	1.07	0.94,1.22	0.98	0.85,1.14	1.04	0.97,1.11	1.06	0.96,1.17
Liver	1.00	0.87	0.77,0.98	0.94	0.75,1.17	0.37	0.25,0.55	0.79	0.70,0.89	0.95	0.80,1.13
Lung	1.00	1.22	1.17,1.27	1.63	1.53,1.74	1.53	1.42,1.65	1.74	1.68,1.81	1.90	1.81,2.00
Prostate	1.00	0.95	0.87,1.05	1.08	0.91,1.28	1.35	1.16,1.57	0.94	0.85,1.03	1.07	0.94,1.23
Bladder	1.00	1.14	1.00,1.31	1.31	1.05,1.65	0.95	0.72,1.25	1.17	1.02,1.33	1.61	1.36,1.91
Malignant melanoma	1.00	0.89	0.74,1.08	1.27	0.95,1.69	1.23	0.86,1.75	0.74	0.61,0.89	0.74	0.56,0.99
Non-preventable cancers											
Pancreas	1.00	0.92	0.84,1.01	0.99	0.84,1.17	1.08	0.90,1.30	0.89	0.81,0.97	0.99	0.86,1.13
Kidney	1.00	1.05	0.93,1.19	1.05	0.84,1.32	1.09	0.85,1.39	0.97	0.86,1.10	0.90	0.74,1.09
Eye, nervous system	1.00	0.99	0.87,1.12	0.94	0.76,1.17	0.97	0.75,1.26	0.85	0.76,0.96	0.85	0.71,1.01
Non-Hodgkin	1.00	0.90	0.78,1.04	1.06	0.83,1.36	1.45	1.13,1.85	0.94	0.82,1.08	0.72	0.57,0.90
Multiple myeloma	1.00	1.07	0.89,1.28	0.79	0.54,1.15	1.75	1.30,2.35	0.92	0.76,1.10	0.99	0.76,1.30
Leukemia	1.00	1.00	0.87,1.15	1.16	0.92,1.47	1.50	1.20,1.88	0.99	0.87,1.13	1.06	0.87,1.28

WOMEN	Managers and professionals	Intermediate white-collar		Service and sales workers		Agricultural and fishery workers		Skilled manual workers		Unskilled manual workers	
Cancer deaths	1.00	1.01	0.97,1.04	1.03	0.98,1.07	1.26	1.14,1.38	1.05	0.99,1.11	1.17	1.12,1.22
Preventable cancers											
Oesophagus	1.00	1.13	0.86,1.50	1.58	1.14,2.19	1.15	0.52,2.51	0.94	0.56,1.60	1.40	1.00,1.97
Colorectal	1.00	1.11	0.99,1.25	1.06	0.91,1.23	0.88	0.61,1.26	1.37	1.15,1.64	1.11	0.95,1.28
Lung	1.00	1.14	1.04,1.25	1.31	1.18,1.47	0.90	0.66,1.22	1.35	1.17,1.55	1.66	1.49,1.84

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Breast	1.00	0.97	0.91,1.04	0.87	0.80,0.94	1.20	1.00,1.45	0.90	0.81,1.01	0.94	0.86,1.02
Cervix	1.00	1.00	0.77,1.29	1.41	1.05,1.89	0.71	0.26,1.94	0.89	0.58,1.37	1.72	1.28,2.30
Uterus	1.00	1.07	0.85,1.35	1.44	1.11,1.87	1.26	0.73,2.18	1.27	0.88,1.83	0.91	0.67,1.23
Bladder	1.00	0.78	0.52,1.15	1.25	0.81,1.93	1.26	0.50,3.15	1.13	0.63,2.04	1.11	0.71,1.73
Malignant melanoma	1.00	1.15	0.89,1.48	0.86	0.60,1.22	1.96	1.05,3.68	1.34	0.92,1.96	1.48	1.09,2.02
Non-preventable cancers											
Stomach	1.00	1.12	0.86,1.48	1.24	0.89,1.72	3.33	1.99,5.55	1.34	0.89,2.02	2.03	1.51,2.72
Liver	1.00	0.97	0.73,1.30	1.04	0.72,1.50	1.44	0.72,2.88	1.11	0.69,1.80	1.50	1.09,2.08
Pancreas	1.00	0.88	0.75,1.02	0.96	0.80,1.16	1.20	0.83,1.73	0.85	0.66,1.11	1.14	0.95,1.36
Ovary	1.00	0.88	0.77,1.00	0.92	0.78,1.08	1.91	1.45,2.50	1.01	0.82,1.25	1.07	0.92,1.26
Kidney	1.00	0.81	0.62,1.06	1.01	0.73,1.39	1.13	0.57,2.24	0.78	0.49,1.25	0.89	0.63,1.25
Eye, nervous system	1.00	0.79	0.66,0.95	0.92	0.73,1.15	1.13	0.68,1.88	0.84	0.62,1.13	1.06	0.85,1.32
Non-Hodgkin	1.00	1.18	0.91,1.53	1.12	0.80,1.55	1.38	0.72,2.64	1.61	1.10,2.37	1.21	0.87,1.67
Multiple myeloma	1.00	1.01	0.73,1.39	1.00	0.67,1.50	1.18	0.53,2.60	0.77	0.43,1.38	0.95	0.63,1.42
Leukemia	1.00	0.95	0.76,1.18	0.97	0.73,1.29	1.26	0.72,2.19	1.13	0.79,1.61	1.15	0.88,1.51

Reference category is managers and professionals
All analyses are adjusted for current age, region and migrant background

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	p. 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	p. 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	p. 3
Objectives	3	State specific objectives, including any prespecified hypotheses	p. 3
Methods			
Study design	4	Present key elements of study design early in the paper	p. 3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	p. 3
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	p. 3
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	p. 3
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	p. 3-4
Bias	9	Describe any efforts to address potential sources of bias	p. 5
Study size	10	Explain how the study size was arrived at	p. 3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	p. 3-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	p. 4-5
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	p. 4
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	p. 5
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	p. 5
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	p. 5
		(b) Indicate number of participants with missing data for each variable of interest	p. 5
		(c) Summarise follow-up time (eg, average and total amount)	p. 5
Outcome data	15*	Report numbers of outcome events or summary measures over time	p. 5
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	p. 5-10
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	p. 11-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	p. 11-12
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	p.10-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	p.10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	p. 13

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Site-specific cancer mortality inequalities by employment and occupational groups: a cohort study among Belgian adults, 2001-2011

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Abstract

Objective: This study probes into site-specific cancer mortality inequalities by employment and occupational group among Belgians, adjusted for other indicators of socioeconomic position.

Design: This cohort study is based on record linkage between the Belgian censuses of 1991 and 2001 and register data on emigration and mortality for 01/10/2001-31/12/2011.

Setting: Belgium

Participants: The study population contains all Belgians within the economically active age (25-65 years) at the census of 1991.

Outcome measures: Both absolute and relative measures were calculated. First, age-standardized mortality rates (ASMR) have been calculated, directly standardized to the Belgian population. Secondly, mortality rate ratios were calculated using Poisson regression, adjusted for education, housing conditions, attained age, region and migrant background.

Results: This study highlights inequalities in site-specific cancer mortality, both related to being employed or not and to the occupational group of the employed population. Unemployed men and women show consistently higher overall and site-specific cancer mortality compared with the employed group. Also within the employed group, inequalities are observed by occupational group. Generally manual workers and service and sales workers have higher site-specific cancer mortality rates compared with white-collar workers and agricultural and fishery workers. These inequalities are manifest for almost all preventable cancer sites, especially those cancer sites related to alcohol- and smoking such as cancers of the lung, oesophagus and head and neck. Overall, occupational inequalities were less pronounced among women compared to men.

Conclusions: Important socioeconomic inequalities in site-specific cancer mortality were observed by employment and occupational group. Ensuring financial security for the unemployed is a key issue in this regard. Future studies could also take a look at other working regimes, for instance temporary employment or part-time employment, and their relation to health.

Article summary

Strengths and limitations of this study

- This paper probes into socioeconomic differences in site-specific cancer mortality, using employment and occupational group as measures of socioeconomic position (SEP), accounting for two other SEP indicators (education and housing conditions).
- The findings are based upon an exhaustive dataset including the total Belgian population within the economically active age range, which provides very rich information on sociodemographic as well as socioeconomic variables and mortality for a follow-up period of 11 years.
- These administrative register data do not contain information on incidence or survival, nor on health behaviours, health care use, or important aspects of the job (e.g. occupational exposures, psychosocial factors).

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INTRODUCTION

In industrialized countries, life expectancy increased during the epidemiological transition, with the most important causes of death (COD) shifting from infectious to chronic diseases such as cancer [1]. This favourable longevity trend went together with an increase in socioeconomic (SE) health inequalities in general [2,3] and with cancer inequalities in particular [4]. According to the fundamental cause theory (FCT), inequalities result from the differential distribution of valuable resources that can be used to avoid adverse health outcomes [2]. This implies that SE inequalities in health will be larger for cancers that are more preventable, either by avoiding risk behaviour or by access to medical interventions [3,5], than for less or non-preventable cancers.

SE inequalities in health are one of the most important challenges for public health policies. Therefore, it is crucial to thoroughly document these inequalities. Up till now, most studies assessing health inequalities have used only one indicator of socioeconomic position (SEP), most often educational attainment or material wealth. However, detailed research on occupational inequalities in site-specific cancer mortality is scarce [6,7], and even non-existent in Belgium. Yet, many studies have shown that, although these SEP indicators are strongly related, they may represent different aspects of SEP [8–10]. Therefore, it is important to establish the role of every single dimension of SEP, for every cancer site separately [9,11,12].

Hence, this paper probes into SE differences in site-specific cancer mortality, using employment and occupational group as measures of SEP, accounting for the other SEP indicators. By doing so, we aim to estimate the net association between employment and occupational group and site-specific cancer mortality in Belgium, which has not yet been studied. Our first research aim is to examine the magnitude of the association between site-specific cancer mortality and employment group, net of one's educational attainment and housing conditions. The second research aim is to assess whether among the employed group, occupational group is associated with site-specific cancer mortality, again net of education and housing conditions. Based on the FCT, we assume that we will observe inequalities by employment and occupational status, especially for the more preventable cancer sites.

DATA AND METHODS

Design and study population

Data are derived from a record linkage between the Belgian censuses of 1991 and 2001 and register data on emigration and cause-specific mortality for the follow-up period 01/10/2001-31/12/2011. This unique population-based dataset includes information on mortality, emigration, COD, sociodemographic (SD) and SE variables of the total de jure population of Belgium.

All SD and SE variables are extracted from the 2001 census, apart from occupational status for which the 1991 census contains the most recent detailed information. All Belgian individuals who are alive at the 2001 census, and who were within the economically active age range (25-65 years) at the census of 1991 are included in the study. For these individuals, we linked information on employment and occupational status, stemming from the 1991 census, irrespective of their employment status at the 2001 census. The study population includes 2,333,479 Belgian women of whom 49% is employed, and 2,231,385 Belgian men, of whom 80% is employed. Age is included as a time-varying covariate to account for age changes during the 11-year follow-up period. To do so, individual follow-up time is split into episodes of 5-year attained age groups using Lexis expansions [13]. Consequently, the age distribution of this population ranges from 35 to 85 years.

Variables

All cancer sites representing at least one per cent of the total cancer mortality are included. Table 1 gives an overview of these cancer sites, the corresponding ICD-10 codes, and the level of preventability. To classify the cancers by level of preventability, we apply the criteria used in Mackenbach's study [14]: amenability to behavioural change and to medical interventions.

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Cancer sites are amenable to behavioural change if the combined population attributable fraction of mortality for overweight and obesity, low fruit and vegetable intake, physical inactivity, unsafe sex, smoking and alcohol consumption was larger than 50% for the European population in the Global Burden of Disease and Risk Factors study [15]. Cancer sites are considered as amenable to medical interventions, if the 5-year relative survival rate for Belgian women and men in the EUROCARE project was higher than 70% between 2000 and 2007 [16] and/or if effective screening is available in Belgium [17].

Table 1. Cancer sites by ICD-10 classification and level of preventability

		Preventable	
	ICD-10	**Men**	**Women**
Malignant neoplasms of:			
Head and neck	C00-C14, C30-C32	Yes	-
Oesophagus	C15	Yes	Yes
Stomach	C16	Yes	No
Colorectum and anus	C18-C21	Yes	Yes
Liver	C22	Yes	No
Pancreas	C25	No	No
Lung, bronchus and trachea	C33-C34	Yes	Yes
Breast	C50	-	Yes
Cervix uteri	C53	-	Yes
Uterus	C54-C55	-	Yes
Ovary	C56	-	No
Prostate	C61	Yes	-
Kidney	C64-C66, C68	No	No
Bladder	C67	Yes	Yes
Eye, brain and central nervous system	C69-C72	No	No
Malignant melanoma	C43-C44	Yes	Yes
Non-Hodgkin Lymphoma	C82-C85	No	No
Multiple myeloma	C90	No	No
Leukaemia	C91-C95	No	No

The empty cells are cancer sites not included for either men or women.

This study probes into cancer mortality inequality among the Belgian population within the economically active age range by using employment and occupational group as a measure of SEP. Both employment and occupational status are derived from the 1991 census and mortality is followed up for the period 2001-2011. Employment status is divided in four categories: employed; unemployed and looking for a job; unemployed and not looking for a job; and disabled. Among the employed, we additionally defined their occupational group, based on the International Standard Classification of Occupations (see table 2) [18]: managers and professionals; intermediate white-collar workers; service and sales workers; agricultural and fishery workers; skilled manual workers; and unskilled manual workers. We choose the employed as a reference category and among the employed the managers and professionals. These choices have been made because of the size of these groups, and because we assume lower cancer mortality for these groups, which facilitates the interpretation.

Statistical analyses

To obtain a full picture of inequalities in cancer mortality, we calculate both absolute and relative measures [19], using complete-case analysis. First, directly age-standardized site-specific mortality rates (ASMR) by employment and occupational group are calculated, using the Belgian population at the 2001 census as standard population. Secondly, mortality rate ratios (MRR) are calculated using Poisson regression. We aim to assess the net effect of employment and occupational group on cancer mortality. Therefore, the Poisson models are adjusted for educational attainment and housing conditions. Educational attainment is categorized using the International Standard Classification of Education: lower secondary education or less (ISCED 0-2, "low"), higher secondary education (ISCED 3-4, "mid"), and

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tertiary education (ISCED 5-6, "high"). Housing conditions is the result of a combination of ownership (tenant or owner) and comfort of the house (low-, mid- and high-comfort), resulting in six categories [20]. Sensitivity analyses are additionally conducted without adjustment for education and housing conditions. These results are not shown but are available in the supplementary file (Tables 1 and 2). Important differences between the crude and net model are mentioned in the discussion section. As there is a strong association in Belgium between mortality and region [21], as well as migration history [22], all Poisson models are adjusted for region (Flanders, Wallonia and Brussels) and migrant background (native versus non-native). All analyses are stratified by sex and are performed using STATA 13.1.

RESULTS

Description of the study population

The study population consists of almost 5 million Belgians within the economically active age range (Table 2). Almost four out of five men are employed, whereas in women about one in two has a paid job.

Table 2. Description of the study population

		Men		Women	
ISCO	**Occupational status**	**Population**	**Cancer deaths**	**Population**	**Cancer deaths**
	Disabled	37,286	2,235	26,905	824
	Unemployed and not looking for a job	295,674	21,704	924,226	25,953
	Employed and looking for a job	121,757	4,418	235,766	2,931
	Employed	1,776,668	34,732	1,146,582	11,943
1-2	Managers and professionals	452,268	8,529	339,663	3,512
3-4	Intermediate white-collar workers	432,803	8,114	384,478	3,761
5	Service and sales workers	92,369	1,837	167,625	1,670
6	Agricultural and fishery workers	52,529	1,352	17,303	282
7-8	Skilled manual workers	556,418	10,990	87,631	858
9	Unskilled manual workers	163,433	3,560	147,887	1,848
	Missing	26,848	350	1,995	12

Absolute cancer mortality rates by employment and occupational status

For almost all preventable cancer sites, men belonging to the employed category have systematically the lowest cancer mortality rates (Table 3). Among the employed men, white-collar workers and agricultural and fishery workers have lower cancer mortality rates compared with manual workers (Table 4). These results hold true for all preventable cancer sites, except for prostate cancer and malignant melanoma for which no inequality is observed. For the non-preventable cancer sites, less inequalities are observed, as expected based upon the FCT. For the non-preventable cancer sites, inequalities generally represent differences between employed versus unemployed.

For women, the absolute inequalities are less pronounced. Generally, mortality from preventable cancer sites is largest for women who are unemployed (Table 3). Among the employed women there are no inequalities, except for lung cancer mortality which is somewhat more elevated for service and sales workers and manual workers compared with female managers (Table 4). On the other hand, service and sales workers have a lower breast cancer mortality rate compared with intermediate white-collar workers. Neither do we observe an occupational inequality pattern for mortality from non-preventable cancer sites. The only exception is stomach cancer mortality, which is highest among the unskilled manual workers.

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Table 3. Absolute site-specific cancer mortality rates (ASMR and 95% C.I.) (2001-2011) among the Belgian population within the economically active age range, by employment group in 1991

MEN	Employed	Unemployed and looking for a job	Unemployed and not looking for a job	Disabled
All cancers	256.9 (253.8-260.0)	436.4 (423.0-449.9)	380.2 (368.6-391.9)	484.3 (462.7-506.0)
Preventable cancers				
Head and neck	11.7 (11.2-12.3)	38.6 (34.7-42.4)	24.8 (20.8-28.7)	31.3 (25.0-37.6)
Oesophagus	10.3 (9.7-10.9)	20.9 (18.0-23.7)	12.8 (10.4-15.2)	15.9 (11.9-19.9)
Stomach	8.2 (7.7-8.8)	11.9 (9.7-14.2)	14.5 (12.0-17.0)	17.0 (12.9-21.0)
Colorectal	25.8 (24.8-26.8)	30.4 (26.8-34.0)	34.3 (30.9-37.6)	33.3 (27.9-38.8)
Liver	7.8 (7.2-8.3)	12.5 (10.3-14.7)	10.8 (8.6-13.0)	13.5 (9.8-17.3)
Lung	88.8 (87.0-90.6)	173.1 (164.6-181.7)	148.8 (141.6-156.0)	195.0 (181.6-208.3)
Prostate	17.2 (16.3-18.1)	17.3 (14.4-20.2)	19.1 (17.6-20.6)	27.9 (23.3-32.4)
Bladder	8.1 (7.5-8.7)	14.5 (12.0-17.1)	11.8 (10.3-13.4)	19.5 (15.2-23.8)
Malignant melanoma	3.0 (2.7-3.3)	3.4 (2.2-4.5)	1.9 (1.2-2.6)	3.3 (1.2-5.3)
Non-preventable cancers				
Pancreas	13.5 (12.8-14.3)	18.3 (15.5-21.1)	15.4 (13.3-17.4)	21.3 (16.5-26.1)
Kidney	7.8 (7.2-8.3)	8.1 (6.3-10.0)	9.0 (7.3-10.8)	12.2 (8.8-15.7)
Eye, nervous system	7.3 (6.8-7.8)	6.9 (5.3-8.5)	8.1 (6.2-10.1)	10.4 (7.0-13.9)
Non-Hodgkin	6.2 (5.7-6.7)	8.4 (6.5-10.3)	6.9 (5.5-8.3)	10.1 (6.7-13.5)
Multiple myeloma	3.8 (3.4-4.2)	3.5 (2.3-4.6)	4.0 (3.1-4.9)	4.5 (2.4-6.6)
Leukemia	7.6 (7.0-8.2)	8.6 (6.6-10.6)	10.1 (8.4-11.8)	9.2 (6.4-12.0)
WOMEN	**Employed**	**Unemployed and looking for a job**	**Unemployed and not looking for a job**	**Disabled**
Cancer deaths	164.7 (160.0-169.4)	200.2 (181.6-218.9)	187.5 (184.8-190.3)	312.4 (286.7-338.1)
Preventable cancers				
Oesophagus	3.3 (2.5-4.0)	3.0 (2.2-3.9)	2.8 (2.5-3.1)	4.7 (2.0-7.3)
Colorectal	15.4 (14.0-16.8)	16.3 (11.6-20.9)	18.5 (17.7-19.2)	35.7 (26.6-44.7)
Lung	23.9 (22.2-25.7)	40.4 (31.6-49.3)	28.7 (27.6-29.9)	51.5 (41.1-61.9)
Breast	41.0 (38.8-43.1)	40.7 (33.4-47.9)	42.4 (41.0-43.8)	70.8 (58.3-83.3)
Cervix	2.8 (2.2-3.3)	7.3 (2.9-11.6)	3.9 (3.4-4.4)	3.8 (0.7-6.9)
Uterus	5.6 (4.6-6.6)	5.0 (3.9-6.1)	6.1 (5.6-6.5)	7.4 (3.9-10.9)
Bladder	1.6 (1.2-2.1)	2.9 (0.0-6.0)	2.5 (2.2-2.8)	7.6 (3.4-11.7)
Malignant melanoma	2.5 (2.0-2.9)	3.8 (0.7-6.9)	2.3 (2.0-2.6)	1.9 (0.3-3.9)
Non-preventable cancers				
Stomach	3.2 (2.6-3.9)	4.4 (1.3-7.5)	4.4 (4.0-4.8)	9.8 (4.7-14.8)
Liver	2.9 (2.3-3.5)	5.6 (1.3-9.9)	4.6 (4.2-5.0)	6.1 (2.7-9.5)
Pancreas	10.4 (9.0-11.7)	8.3 (5.0-11.5)	10.9 (10.3-11.5)	14.5 (9.1-19.9)
Ovary	13.4 (12.0-14.7)	9.0 (7.6-10.5)	12.4 (11.7-13.1)	13.2 (8.1-18.3)
Kidney	2.8 (2.2-3.4)	5.8 (1.4-10.1)	4.3 (3.9-4.7)	6.8 (3.9-9.7)
Eye, nervous system	5.3 (4.5-6.1)	5.4 (2.3-8.5)	5.7 (5.2-6.3)	11.1 (6.2-16.0)
Non-Hodgkin	3.9 (3.1-4.7)	4.6 (1.5-7.8)	4.6 (4.2-5.0)	7.2 (2.7-11.8)
Multiple myeloma	2.7 (2.0-3.4)	3.2 (0.1-6.3)	3.3 (2.9-3.6)	2.1 (0.2-4.0)
Leukemia	5.0 (4.1-5.9)	2.6 (1.8-3.4)	5.3 (4.9-5.7)	8.7 (3.9-13.6)

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Table 4. Absolute site-specific cancer mortality rates (ASMR and 95% C.I.) (2001-2011) among the Belgian employed population, by occupational group in 1991

MEN	Managers and professionals	Intermediate white-collar	Service and sales workers	Agricultural and fishery workers	Skilled manual workers	Unskilled manual workers
All cancers	163.3 (159.8-166.9)	190.0 (185.9-194.1)	232.3 (221.6-242.9)	177.6 (166.5-188.7)	228.4 (224.0-232.8)	246.3 (238.1-254.4)
Preventable cancers						
Head and neck	8.2 (7.4-9.0)	10.1 (9.2-11.0)	14.7 (12.1-17.3)	9.8 (6.9-12.8)	12.4 (11.4-13.3)	17.0 (14.9-19.1)
Oesophagus	7.6 (6.9-8.4)	8.5 (7.6-9.3)	9.3 (7.2-11.4)	6.4 (4.2-8.7)	9.4 (8.5-10.3)	10.2 (8.5-11.8)
Stomach	5.2 (4.6-5.8)	6.2 (5.4-6.9)	5.4 (3.8-7.1)	6.1 (4.1-8.1)	7.9 (7.1-8.7)	8.3 (6.8-9.9)
Colorectal	17.5 (16.4-18.6)	19.0 (17.7-20.3)	21.2 (17.9-24.4)	13.6 (10.6-16.5)	20.5 (19.1-21.8)	20.3 (17.9-22.7)
Liver	6.3 (5.6-7.0)	6.0 (5.2-6.7)	6.7 (4.9-8.5)	2.0 (0.8-3.2)	5.5 (4.8-6.2)	7.0 (5.7-8.4)
Lung	48.0 (46.1-49.9)	62.8 (60.5-65.2)	84.8 (78.4-91.3)	65.1 (58.4-71.9)	91.1 (88.3-93.8)	97.1 (91.9-102.2)
Prostate	9.6 (8.8-10.4)	10.2 (9.2-11.2)	11.5 (9.0-13.9)	9.5 (7.3-11.7)	10.6 (9.6-11.7)	11.4 (9.5-13.2)
Bladder	4.7 (4.1-5.3)	5.8 (5.1-6.6)	7.0 (5.1-8.9)	4.0 (2.4-5.5)	6.0 (5.3-6.7)	8.2 (6.6-9.7)
Malignant melanoma	2.9 (2.4-3.4)	2.7 (2.2-3.2)	3.8 (2.4-5.1)	3.0 (1.4-4.6)	2.4 (2.0-2.8)	2.2 (1.4-2.9)
Non-preventable cancers						
Pancreas	10.7 (9.8-11.6)	10.2 (9.2-11.2)	11.6 (9.2-14.0)	10.3 (7.5-13.0)	10.1 (9.1-11.0)	11.0 (9.3-12.8)
Kidney	5.5 (4.9-6.2)	6.2 (5.5-7.0)	6.0 (4.3-7.7)	5.4 (3.6-7.3)	6.0 (5.3-6.7)	5.4 (4.2-6.6)
Eye, nervous system	6.5 (5.8-7.3)	6.8 (6.0-7.5)	6.9 (5.1-8.7)	5.3 (3.3-7.3)	6.2 (5.5-6.9)	6.0 (4.7-7.2)
Non-Hodgkin	4.6 (4.0-5.1)	4.5 (3.9-5.1)	5.3 (3.7-6.9)	6.7 (4.4-9.0)	4.8 (4.2-5.5)	3.5 (2.5-4.5)
Multiple myeloma	2.5 (2.1-3.0)	3.0 (2.5-3.5)	2.5 (1.3-3.6)	3.4 (1.9-4.9)	2.6 (2.1-3.0)	3.1 (2.2-4.0)
Leukemia	4.9 (4.3-5.5)	5.2 (4.5-5.9)	6.7 (4.9-8.5)	6.0 (4.1-7.9)	5.5 (4.8-6.2)	5.7 (4.5-7.0)

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Table 4. Continued

WOMEN	Managers and professionals	Intermediate white-collar	Service and sales workers	Agricultural and fishery workers	Skilled manual workers	Unskilled manual workers
Cancer deaths	98.2 (95.0-101.5)	106.1 (102.7-109.6)	101.9 (97.0-106.8)	92.9 (79.0-106.8)	107.7 (100.2-115.1)	111.1 (106.0-116.2)
Preventable cancers						
Oesophagus	1.3 (0.9-1.6)	1.7 (1.3-2.2)	2.2 (1.4-2.9)	1.5 (0.0-3.2)	1.2 (0.4-2.0)	1.8 (1.1-2.4)
Colorectal	8.3 (7.3-9.2)	9.9 (8.8-11.0)	8.6 (7.2-10.0)	5.6 (2.5-8.7)	11.4 (9.0-13.8)	8.3 (6.9-9.6)
Lung	13.5 (12.3-14.7)	16.5 (15.2-17.8)	17.9 (15.9-20.0)	8.6 (4.5-12.8)	17.2 (14.3-20.1)	22.2 (19.9-24.5)
Breast	30.3 (28.5-32.1)	32.1 (30.2-33.9)	26.6 (24.1-29.1)	28.9 (20.6-37.3)	30.1 (26.2-33.9)	27.7 (25.1-30.3)
Cervix	1.9 (1.4-2.3)	1.8 (1.4-2.3)	2.6 (1.8-3.3)	1.4 (0.0-3.1)	1.9 (0.9-2.8)	3.0 (2.1-3.9)
Uterus	2.4 (1.9-2.9)	2.6 (2.0-3.1)	3.3 (2.4-4.2)	1.6 (0.4-2.8)	3.7 (2.1-5.2)	2.0 (1.4-2.7)
Bladder	0.8 (0.5-1.1)	0.8 (0.5-1.1)	1.1 (0.6-1.6)	0.5 (0.0-1.2)	0.9 (0.2-1.7)	1.0 (0.5-1.5)
Malignant melanoma	1.8 (1.4-2.3)	2.1 (1.6-2.6)	1.7 (1.0-2.3)	3.0 (0.2-5.7)	2.3 (1.3-3.4)	2.3 (1.5-3.0)
Non-preventable cancers						
Stomach	1.6 (1.2-2.0)	1.8 (1.3-2.2)	1.8 (1.2-2.5)	5.4 (1.8-9.0)	2.2 (1.1-3.3)	3.1 (2.3-4.0)
Liver	1.4 (1.0-1.8)	1.5 (1.1-1.9)	1.7 (1.1-2.3)	1.4 (0.0-2.9)	1.5 (0.6-2.4)	2.1 (1.4-2.8)
Pancreas	5.5 (4.7-6.3)	5.2 (4.4-5.9)	5.5 (4.4-6.7)	3.1 (1.5-4.8)	4.8 (3.2-6.4)	5.6 (4.5-6.8)
Ovary	7.4 (6.5-8.3)	7.2 (6.3-8.1)	7.0 (5.7-8.2)	10.4 (6.0-14.9)	8.5 (6.4-10.6)	8.3 (6.9-9.7)
Kidney	1.9 (1.4-2.3)	1.5 (1.1-2.0)	1.8 (1.2-2.5)	1.7 (0.0-3.4)	1.6 (0.7-2.5)	1.5 (1.0-2.1)
Eye, nervous system	4.1 (3.4-4.8)	3.5 (2.9-4.1)	3.6 (2.7-4.5)	4.2 (0.8-7.5)	3.3 (2.1-4.5)	4.1 (3.2-5.1)
Non-Hodgkin	1.8 (1.3-2.2)	2.2 (1.7-2.7)	1.9 (1.3-2.6)	1.7 (0.0-3.5)	2.8 (1.6-4.0)	2.0 (1.3-2.7)
Multiple myeloma	1.2 (0.8-1.5)	1.3 (0.9-1.7)	1.2 (0.7-1.7)	2.6 (0.0-5.5)	1.0 (0.2-1.7)	1.2 (0.6-1.7)
Leukemia	2.4 (1.9-2.9)	2.6 (2.0-3.1)	2.6 (1.8-3.4)	2.9 (0.4-5.5)	3.3 (1.9-4.8)	2.8 (2.0-3.7)

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Table 5. Net relative site-specific cancer mortality inequality (MRR and 95% C.I.) (2001-2011) among the Belgian population within the economically active age range, by employment group in 1991

MEN	Employed	Unemployed and looking for a job		Unemployed and not looking for a job		Disabled	
All cancers	1.00	1.60	1.55,1.65	2.74	2.69,2.80	2.28	2.19,2.37
Preventable cancers							
Head and neck	1.00	2.33	2.10,2.59	2.73	2.46,3.02	2.18	1.80,2.65
Oesophagus	1.00	2.09	1.83,2.38	2.36	2.12,2.62	1.98	1.59,2.48
Stomach	1.00	1.35	1.13,1.61	2.97	2.68,3.30	2.65	2.15,3.28
Colorectal	1.00	1.26	1.14,1.41	2.61	2.45,2.77	1.71	1.48,1.99
Liver	1.00	1.49	1.25,1.76	2.31	2.06,2.60	2.29	1.82,2.88
Lung	1.00	1.71	1.63,1.79	2.86	2.77,2.95	2.52	2.37,2.69
Prostate	1.00	1.17	1.01,1.35	2.78	2.59,2.99	2.30	1.96,2.70
Bladder	1.00	1.91	1.62,2.25	3.37	3.05,3.73	2.65	2.13,3.29
Malignant melanoma	1.00	1.30	0.97,1.73	1.90	1.57,2.31	1.05	0.59,1.88
Non-preventable cancers							
Pancreas	1.00	1.38	1.21,1.58	2.44	2.24,2.66	1.85	1.53,2.25
Kidney	1.00	1.18	0.97,1.45	2.39	2.14,2.68	2.52	2.01,3.16
Eye, nervous system	1.00	0.94	0.75,1.17	2.14	1.88,2.44	2.15	1.64,2.82
Non-Hodgkin	1.00	1.35	1.09,1.66	2.42	2.13,2.75	1.79	1.33,2.43
Multiple myeloma	1.00	1.25	0.93,1.68	2.86	2.46,3.32	1.48	0.97,2.25
Leukemia	1.00	1.05	0.84,1.31	2.73	2.44,3.06	1.72	1.30,2.28
WOMEN	**Employed**	**Unemployed and looking for a job**		**Unemployed and not looking for a job**		**Disabled**	
Cancer deaths	1.00	1.11	1.07,1.15	1.74	1.71,1.78	1.96	1.83,2.09
Preventable cancers							
Oesophagus	1.00	1.35	1.04,1.75	1.67	1.40,1.99	1.94	1.15,3.26
Colorectal	1.00	1.09	0.97,1.23	1.79	1.68,1.92	2.23	1.83,2.73
Lung	1.00	1.19	1.10,1.29	1.61	1.53,1.70	1.82	1.54,2.14
Breast	1.00	1.02	0.95,1.09	1.64	1.57,1.71	1.93	1.68,2.22
Cervix	1.00	1.78	1.45,2.18	1.85	1.57,2.19	0.90	0.42,1.91
Uterus	1.00	1.36	1.11,1.67	2.12	1.86,2.40	1.83	1.22,2.75
Bladder	1.00	1.07	0.73,1.56	1.99	1.63,2.43	3.20	1.92,5.34
Malignant melanoma	1.00	1.02	0.79,1.32	1.35	1.14,1.59	1.09	0.54,2.21
Non-preventable cancers							
Stomach	1.00	1.03	0.81,1.31	1.70	1.48,1.96	2.26	1.50,3.40
Liver	1.00	1.10	0.84,1.44	2.31	1.99,2.68	1.63	0.98,2.70
Pancreas	1.00	0.94	0.80,1.11	1.76	1.61,1.92	1.65	1.23,2.22
Ovary	1.00	0.99	0.86,1.14	1.56	1.44,1.69	1.13	0.82,1.56
Kidney	1.00	1.21	0.93,1.57	2.04	1.76,2.35	3.33	2.28,4.87
Eye, nervous system	1.00	0.79	0.64,0.98	1.61	1.43,1.80	1.39	0.89,2.18
Non-Hodgkin	1.00	0.99	0.76,1.29	1.96	1.70,2.25	1.54	0.95,2.52
Multiple myeloma	1.00	0.93	0.65,1.34	2.33	1.96,2.77	1.32	0.65,2.69
Leukemia	1.00	0.75	0.57,0.97	1.66	1.46,1.88	1.35	0.85,2.15

Reference category is employed
All analyses are adjusted for current age, region, migrant background, educational attainment and housing conditions

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Table 6. Net relative site-specific cancer mortality inequality (MRR and 95% C.I.) (2001-2011) among the Belgian employed population, by occupational group in 1991

MEN	Managers and professionals	Intermediate white-collar		Service and sales workers		Agricultural and fishery workers		Skilled manual workers		Unskilled manual workers	
All cancers	1.00	0.93	0.91,0.96	0.95	0.91,0.99	0.93	0.88,0.97	0.90	0.87,0.93	0.94	0.90,0.97
Preventable cancers											
Head and neck	1.00	0.92	0.82,1.04	1.03	0.86,1.23	0.67	0.52,0.88	0.83	0.73,0.95	1.13	0.98,1.32
Oesophagus	1.00	0.90	0.80,1.01	0.84	0.68,1.04	0.66	0.50,0.87	0.83	0.73,0.95	0.87	0.73,1.04
Stomach	1.00	0.98	0.85,1.13	0.88	0.68,1.14	0.99	0.74,1.33	0.99	0.84,1.16	1.03	0.84,1.27
Colorectal	1.00	0.89	0.82,0.97	0.80	0.69,0.93	0.80	0.68,0.94	0.79	0.72,0.86	0.83	0.73,0.94
Liver	1.00	0.73	0.63,0.84	0.54	0.41,0.72	0.24	0.15,0.39	0.56	0.48,0.65	0.64	0.52,0.79
Lung	1.00	0.97	0.93,1.02	1.04	0.97,1.12	0.98	0.90,1.07	1.07	1.02,1.12	1.05	0.99,1.12
Prostate	1.00	0.87	0.78,0.97	0.83	0.68,1.01	1.11	0.92,1.34	0.75	0.67,0.85	0.86	0.73,1.01
Bladder	1.00	0.93	0.79,1.08	0.94	0.72,1.22	0.74	0.54,1.01	0.85	0.72,1.00	1.08	0.88,1.34
Malignant melanoma	1.00	0.86	0.70,1.04	1.11	0.81,1.53	1.11	0.76,1.62	0.53	0.42,0.66	0.62	0.45,0.84
Non-preventable cancers											
Pancreas	1.00	0.88	0.79,0.98	0.84	0.69,1.01	0.94	0.76,1.15	0.74	0.66,0.83	0.78	0.67,0.92
Kidney	1.00	0.94	0.82,1.08	0.85	0.66,1.10	0.85	0.64,1.14	0.77	0.66,0.90	0.64	0.51,0.81
Eye, nervous system	1.00	0.93	0.81,1.06	0.87	0.69,1.11	0.93	0.70,1.23	0.70	0.61,0.82	0.70	0.56,0.87
Non-Hodgkin	1.00	0.85	0.73,1.00	1.00	0.76,1.31	1.32	0.99,1.76	0.83	0.69,0.99	0.72	0.55,0.93
Multiple myeloma	1.00	1.09	0.90,1.34	0.69	0.44,1.07	1.55	1.09,2.22	0.82	0.65,1.04	0.90	0.65,1.25
Leukemia	1.00	0.95	0.81,1.11	1.13	0.87,1.47	1.33	1.01,1.74	0.90	0.76,1.07	0.95	0.75,1.20

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Table 6. Continued

WOMEN	Managers and professionals	Intermediate white-collar		Service and sales workers		Agricultural and fishery workers		Skilled manual workers		Unskilled manual workers	
Cancer deaths	1.00	0.89	0.86,0.93	0.79	0.75,0.83	0.91	0.82,1.02	0.77	0.72,0.82	0.83	0.79,0.88
Preventable cancers											
Oesophagus	1.00	0.86	0.60,1.22	1.02	0.66,1.59	0.94	0.39,2.25	0.56	0.29,1.07	0.95	0.60,1.52
Colorectal	1.00	1.00	0.88,1.15	0.84	0.70,1.01	0.66	0.43,1.01	1.04	0.85,1.29	0.86	0.71,1.03
Lung	1.00	0.89	0.80,0.99	0.82	0.72,0.94	0.48	0.33,0.70	0.78	0.66,0.92	0.86	0.75,0.98
Breast	1.00	0.93	0.86,1.00	0.74	0.67,0.82	1.03	0.84,1.27	0.75	0.66,0.85	0.75	0.67,0.84
Cervix	1.00	0.79	0.57,1.08	0.78	0.53,1.15	0.44	0.14,1.41	0.54	0.33,0.88	0.80	0.55,1.18
Uterus	1.00	0.91	0.70,1.19	1.07	0.78,1.47	0.68	0.32,1.42	0.91	0.59,1.42	0.70	0.48,1.02
Bladder	1.00	0.93	0.59,1.47	1.68	0.95,2.98	1.69	0.57,4.97	1.61	0.81,3.22	1.48	0.78,2.81
Malignant melanoma	1.00	1.07	0.81,1.40	0.68	0.45,1.03	0.76	0.31,1.88	0.95	0.61,1.47	1.03	0.72,1.49
Non-preventable cancers											
Stomach	1.00	1.03	0.76,1.41	0.90	0.61,1.35	1.68	0.87,3.21	0.87	0.52,1.43	1.67	1.16,2.40
Liver	1.00	0.78	0.56,1.10	0.64	0.41,0.99	0.27	0.06,1.14	0.71	0.40,1.24	1.07	0.72,1.59
Pancreas	1.00	0.80	0.67,0.95	0.76	0.61,0.96	0.82	0.52,1.31	0.72	0.53,0.98	0.89	0.70,1.12
Ovary	1.00	0.76	0.65,0.88	0.79	0.64,0.96	1.63	1.20,2.21	0.82	0.64,1.04	0.79	0.64,0.97
Kidney	1.00	0.54	0.39,0.74	0.70	0.47,1.03	1.04	0.52,2.09	0.59	0.36,0.98	0.62	0.41,0.94
Eye, nervous system	1.00	0.73	0.59,0.90	0.80	0.62,1.05	1.16	0.69,1.95	0.71	0.50,1.00	0.72	0.53,0.97
Non-Hodgkin	1.00	1.01	0.75,1.35	0.78	0.53,1.15	1.33	0.69,2.59	1.09	0.69,1.72	0.82	0.56,1.21
Multiple myeloma	1.00	0.98	0.70,1.38	0.91	0.57,1.45	0.77	0.27,2.17	0.71	0.35,1.43	0.80	0.49,1.30
Leukemia	1.00	0.87	0.68,1.12	0.75	0.53,1.07	0.89	0.47,1.69	0.77	0.51,1.18	0.89	0.64,1.24

Reference category is managers and professionals
All analyses are adjusted for current age, region, migrant background, educational attainment and housing conditions

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Relative cancer mortality inequality by employment and occupational status

In this paragraph, we present the results of the net relative models, adjusted for education and housing conditions. Unemployed men and women have higher site-specific cancer mortality rates compared with employed people (Table 5). This holds true for preventable and non-preventable cancers and are especially observed among the unemployed that are not looking for a job. To illustrate this with an example: unemployed men that are not looking for a job have a three times higher chance of dying from bladder cancer (MRR: 3.37; 95% C.I.: 3.05-3.73) compared with employed men. For most cancer sites (mainly the preventable cancers) particularly unemployed men and women that are either not looking for a job or disabled have consistently higher cancer mortality rates compared with employed men and women.

Within the employed population inequalities by occupation are also observed although more in men than in women (Table 6). In men, managers appear to have higher colorectal and liver cancer mortality rates compared with men in other occupations. Furthermore, lower mortality rates in favour of manual workers are observed for several non-preventable cancer sites, amongst others cancer of the pancreas and kidney. Compared with male managers skilled manual workers have a 7% higher lung cancer mortality rate. Another interesting observation is the mortality pattern of the agricultural and fishery workers. Compared with managers, they tend to die less from preventable cancers such as head and neck and oesophageal cancers. Their liver cancer mortality rate is even 76% lower compared with managers (MRR: 0.24; 95% C.I.: 0.15-0.39). In contrast, agricultural and fishery workers show higher mortality from some non-preventable cancer sites such as leukaemia and multiple myeloma. Female manual workers and service and sales workers have about 25% lower breast cancer mortality rates compared with female managers.

DISCUSSION AND CONCLUSION

Methodological issues

The findings are based upon a high-quality and exhaustive dataset including the total Belgian population within the economically active age range. A numerator-denominator bias was eliminated through record linkage between census and register data. This dataset provides very rich information on SD as well as SE variables and mortality for a follow-up period of 11 years. This enables us to give precise estimates of site-specific cancer mortality inequalities at the individual level. However, these register data do not contain information on incidence or survival, nor on health behaviours, health care use, or important aspects of the job (e.g. occupational exposures, psychosocial factors), which are all likely to be associated with cancer outcomes [23]. Therefore it is difficult to make solid conclusions on the relative importance of all these factors to explain the observed SE inequalities in cancer mortality [23,24].

We included the total Belgian population that belonged to the economically active age group (25-65 years) at the census of 1991, independently of their actual occupational status. We decided so because we were interested in the association between cancer mortality and both employment and occupational group. By doing so, we avoided a selection effect due to including only the healthy workers [6,25–28]. Our results indicate the importance of this issue, showing highest (site-specific) cancer mortality among the unemployed groups. Nevertheless, we cannot fully exclude a selection effect among the employed population because we can assume that unhealthy persons are less frequently employed in physically demanding jobs [26,27]. A healthy worker effect might then be more likely in the groups of manual workers, which could partly explain some of the observed mortality patterns in favour of manual workers. On the other hand, the white-collar workers may have less physically demanding jobs, which can counter this effect. Occupational information was derived from the census of 1991, which is the most recent source of detailed information since the census of 2001 does not contain detailed occupational information. Because of the lag time between some (occupational) exposures and cancer mortality, we do not consider this as a problem [29]. Due to the cross-sectional nature of this information, the occupation is not necessarily the longest job respondents were involved in, nor do we have information on the duration of this occupation [25]. However, occupation was

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grouped into broad groups, which leads us to assume that the bias due to transitions between occupational categories will be rather small [30].

We decided not to use the robust distinction between manual versus non-manual workers, nor did we focus on one specific cancer site in relation to one or more job exposures. These choices have been made in order to gain insights into the overall association between occupational status and cancer mortality [26]. Many studies assessing SE inequalities in cancer mortality use only one SE indicator at a time although the importance of including multiple indicators has already been pointed out [9,11,12] because different SEP indicators tap into different pathways [8–10]. Housing conditions are related to material and financial resources, and therefore to healthcare utilisation [31]. Education captures the human capital acquired early in life and may be related to the ability to adapt health education messages, and hence to health behaviours [6]. Occupational status on the other hand reflects the ability to realize this human capital in the labour market, and is rather a reflection of one's social class at older ages. Employment as well as occupation is likely to (partially) capture material resources, access to health care as well as social networks and work-related factors such as stress, autonomy and occupational hazards. Hence, we need to analyse all aspects of SEP in relation to health outcomes, although these indicators are closely related [6]. In this paper, we focus on the net effect of occupational status, thereby adjusting for educational attainment and housing conditions. The results indicate an association between occupational status and site-specific cancer mortality, independently of education and housing conditions.

Finally, we classified the cancer sites by their level of preventability (see Methods). We acknowledge that this classification does not exclude the fact that some "non-preventable" cancers are also related to behavioural change and/or medical interventions, nor does it eliminate some possible overlap between these two criteria of preventability. However, to enhance the comparability with other studies, we decided to adopt this often-used classification.

Theoretical considerations on the main findings

This study reveals inequalities in site-specific cancer mortality by employment and occupational groups. Generally SE inequalities are less pronounced in women compared with men, which is consistent with the literature [7,23,28]. The unemployed group (and especially those not looking for a job) shows both for men and women higher cancer mortality rates compared with the employed, which is in line with previous studies in France and the UK [23,32]. Possible explanations are financial insecurity, which is related to a lower use of health care services, and an unhealthy lifestyle [32]. Some studies suggest that part of this association between unemployment and health might be due to health selection [23], although others observed an ongoing effect after adjustment for pre-existing morbidity [32]. However, it is very likely that for the unemployed that are not looking for a job, as well as for the disabled group, health selection will be at play.

Also within the employed group, inequalities by occupational group are observed. In men these findings are in line with the FCT which expects larger inequalities for more preventable cancer sites [3,5]. The absolute results show that male manual workers have the highest site-specific cancer mortality rates whereas white-collar workers and agricultural and fishery workers have the lowest cancer mortality rates. This discrepancy between manual and non-manual workers is in line with previous findings in Europe [6,33]. These absolute inequalities are manifest for all preventable cancer sites (except for non-malignant melanoma and prostate cancer), with alcohol- and smoking-related cancers (e.g. cancers of the lung, head and neck and bladder) being the main contributors to these inequalities, as reported in previous studies [25,28,30,33,34]. The excess mortality for cancers of the head and neck and lung are also observed for male service and sales workers, which can be explained by the higher likelihood of occupational exposure to tobacco and alcohol in bars and restaurants [27]. Another interesting finding is the favourable cancer mortality pattern for farmers, which might be related to their healthy life style with less tobacco and alcohol use and more physical activity [35,36].

According to the FCT, the availability of valuable resources such as knowledge, money, power, prestige and beneficial social connections are the social causes of health inequalities [2]. When there is sound knowledge of the causes and cures of cancers, those in high SEP contexts, with greater access to resources, will disproportionally benefit from this knowledge. Several mechanisms have been suggested to explain this association, such as a differential acquisition of knowledge on health-damaging behaviours (e.g. smoking, bad diet, alcohol intake or a lack of exercise) [6,7,10,23,26,37]. Also material factors are important: having financial difficulties might be related to poor living conditions [7,23,30] or the inability to optimise the use of health services [10,33,37]. Both access to and quality of health care are crucial for health outcomes in all stages, from prevention (e.g. through cancer screening) to treatment. Finally, the social aspect of SEP is associated with health, for example stress-related factors or the level of social prestige [25]. Since we cannot adjust for health behaviours or health care use, it remains difficult to decide on the extent of inequalities due to each of these mechanisms [26]. Yet, our findings showed that the inequalities were especially large for the preventable cancer sites related to health behaviours such as smoking and alcohol use. Previous studies indeed reported higher smoking prevalence among manual workers and people working in the catering industry [38]. However, studies mediating the observed gradients for smoking reported an attenuated but still significant relation between SEP and mortality [7,24,30], which assumes that there might be other factors at play as well. Sensitivity analyses not adjusting for education and housing conditions showed both for men and women lowest lung cancer mortality among the managers compared with all other occupational groups (supplementary file, table 2). However, in the models adjusted for education and housing conditions (presented in table 6), the association reversed for women, whereas for men lung cancer mortality only remains somewhat higher for male skilled manual workers, which could be related to occupational exposures. In contrary, in the adjusted model higher breast cancer mortality rates were observed in female managers compared with all other occupations except sales and service workers. This can be explained by differences in reproductive behaviour, with less children and a later age at first birth for the white-collar occupations [24,28]. In the net model, male managers had higher colorectal and liver cancer mortality compared with all other occupations. Yet, in the unadjusted model, the association between occupation and colorectal cancer mortality disappeared (supplementary file, table 2). Moreover, compared with the white-collar occupations, manual workers do have lower mortality for several other cancer sites (e.g. malignant melanoma and kidney). These results are counterintuitive, suggesting that there are other factors at play, such as an unhealthy and sedentary lifestyle of managers [39,40].

We can assume that the results of the net model are more likely to be due to differences related to the job itself. Yet, a healthy lifestyle may be induced by the social environment (e.g. the colleagues at work), and therefore might not be excluded as a potential mechanism [6]. Specific occupational exposures and hazards may explain part of the association between occupational status and health [7,10,23]. Another important aspect of work related to health is the psychosocial aspect of the job, such as the sense of control and autonomy, the level of job strain, or long working hours [7,23,25,30,41]. This could be an explanation for the excessive colorectal cancer mortality among male managers. Colorectal cancer is associated with perceived stress, and could therefore be related to the long working hours and work strain as perceived by managers [39,41].

Implications and conclusions

This paper highlights important SE inequalities in site-specific cancer mortality by employment and occupational groups. Being unemployed, and among the employed, being employed as a manual worker or service and sales worker is associated with higher overall and site-specific cancer mortality. These unfavourable mortality patterns among the unemployed and manual and service and sales workers were especially observed for the more preventable cancers, as we assumed based upon the FCT. These occupational inequalities change when other SEP indicators are adjusted for. Multiple SEP indicators should be taken into account when studying

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SE inequalities in health [9,11,12] because these allow for different causal pathways [8–10]. Yet, it is difficult to identify to what extent the potential explanatory factors attribute to these inequalities because we do not dispose of data on incidence or survival, nor on data on risk factors, health care use, or job characteristics. Future studies having access to these kind of data could help to unravel the complex interplay between incidence, survival and mortality, and to clarify at which steps the social differences operate [23,24].

This study can be helpful in providing evidence for policy makers in order to reduce SE inequalities in cancer mortality [37]. Our results prove that there is still a long way to go. We observed for example that the unemployed groups are at a much higher risk of dying from cancer compared with the employed population. Ensuring financial security for the unemployed is a key issue in this regard [32]. Future research could also study other working regimes, e.g. temporary or part-time employment, and their relation to health. Finally, there could be an important role for the general practitioner to make sure that the unemployed are getting the health care they need [32]. Also for the high-risks jobs, regular health checks at the work floor are needed in order to detect cancers at an early stage.

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Competing interests

We have read and understood the BMJ policy on the declaration of interests and declare that we have no competing interests.

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Authors' contributions

KV designed and conducted the study and wrote the first draft of the manuscript. LVdB, HV, PH and SG helped with the interpretation of the results and critically revised this first draft. KV, LvDB, HV, PH and SG approved the final version of the manuscript.

Data sharing statement

Analyses are based on administrative data from the Belgian Census, the Belgian mortality register and death certificates provided by Statistics Belgium. The availability of the data is restricted. Permission for analyses must be granted after verification of the research goals by the Belgian Commission for the protection of privacy.

Ethical approval

This research as well as the data adhere to the ethical code of scientific research in Belgium, see: http://www.belspo.be/belspo/organisation/publ/pub_ostc/Eth_code/ethcode_nl.pdf.
All authors have signed the ethical code.

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Table 1. Unadjusted relative site-specific cancer mortality inequality (MRR and 95% C.I.) (2001-2011) among the Belgian population within the economically active age range, by employment group in 1991

MEN	Employed	Unemployed and looking for a job		Unemployed and not looking for a job		Disabled	
All cancers	1.00	1.96	1.92,2.01	3.07	3.02,3.12	2.69	2.60,2.78
Preventable cancers							
Head and neck	1.00	3.65	3.35,3.97	3.39	3.11,3.70	3.30	2.84,3.84
Oesophagus	1.00	2.41	2.16,2.69	2.61	2.38,2.87	2.11	1.74,2.55
Stomach	1.00	1.53	1.32,1.78	3.24	2.96,3.55	3.12	2.63,3.71
Colorectal	1.00	1.45	1.33,1.59	2.79	2.64,2.94	1.89	1.67,2.13
Liver	1.00	1.74	1.51,2.00	2.38	2.15,2.64	2.26	1.85,2.76
Lung	1.00	2.25	2.16,2.34	3.45	3.35,3.55	3.20	3.04,3.37
Prostate	1.00	1.27	1.13,1.44	2.82	2.65,3.00	2.64	2.32,3.00
Bladder	1.00	2.14	1.86,2.45	3.46	3.17,3.77	3.53	2.99,4.15
Malignant melanoma	1.00	1.29	0.99,1.66	1.77	1.49,2.10	1.32	0.86,2.04
Non-preventable cancers							
Pancreas	1.00	1.49	1.33,1.68	2.61	2.43,2.82	2.03	1.73,2.39
Kidney	1.00	1.26	1.06,1.50	2.45	2.21,2.71	2.45	2.01,2.99
Eye, nervous system	1.00	1.00	0.83,1.20	2.15	1.91,2.41	1.96	1.55,2.49
Non-Hodgkin	1.00	1.56	1.31,1.85	2.48	2.21,2.77	2.09	1.64,2.66
Multiple myeloma	1.00	1.22	0.95,1.57	2.76	2.42,3.15	1.79	1.30,2.46
Leukemia	1.00	1.19	1.00,1.43	2.80	2.54,3.09	1.88	1.50,2.36

WOMEN	Employed	Unemployed and looking for a job		Unemployed and not looking for a job		Disabled	
Cancer deaths	1.00	1.25	1.21,1.28	1.91	1.88,1.95	2.29	2.17,2.42
Preventable cancers							
Oesophagus	1.00	1.69	1.36,2.09	1.74	1.49,2.02	2.18	1.42,3.35
Colorectal	1.00	1.19	1.07,1.32	1.93	1.82,2.05	2.52	2.14,2.98
Lung	1.00	1.52	1.41,1.63	1.92	1.83,2.01	2.43	2.12,2.78
Breast	1.00	1.04	0.98,1.11	1.72	1.65,1.78	1.97	1.75,2.21
Cervix	1.00	2.12	1.78,2.54	2.31	2.00,2.67	1.64	0.96,2.81
Uterus	1.00	1.61	1.35,1.93	2.27	2.02,2.54	2.28	1.64,3.18
Bladder	1.00	1.12	0.80,1.57	2.32	1.94,2.77	4.94	3.40,7.18
Malignant melanoma	1.00	1.11	0.88,1.41	1.38	1.20,1.60	1.23	0.69,2.20
Non-preventable cancers							
Stomach	1.00	1.18	0.95,1.48	2.09	1.84,2.37	2.90	2.07,4.08
Liver	1.00	1.25	0.98,1.59	2.65	2.32,3.04	2.83	1.97,4.06
Pancreas	1.00	1.01	0.88,1.17	1.80	1.67,1.94	1.86	1.47,2.36
Ovary	1.00	1.03	0.91,1.16	1.63	1.52,1.75	1.36	1.05,1.75
Kidney	1.00	1.21	0.94,1.54	2.31	2.02,2.64	3.38	2.42,4.73
Eye, nervous system	1.00	0.88	0.73,1.06	1.72	1.55,1.90	2.26	1.67,3.07
Non-Hodgkin	1.00	1.14	0.90,1.44	2.18	1.92,2.47	1.84	1.23,2.77
Multiple myeloma	1.00	0.91	0.65,1.25	2.33	2.00,2.71	0.99	0.50,1.93
Leukemia	1.00	0.76	0.60,0.96	1.82	1.63,2.04	1.72	1.20,2.47

Reference category is employed
All analyses are adjusted for current age, region and migrant background

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Table 2. Relative site-specific cancer mortality inequality (MRR and 95% C.I.) (2001-2011) among the Belgian employed population, by occupational group in 1991

MEN	Managers and professionals	Intermediate white-collar		Service and sales workers		Agricultural and fishery workers		Skilled manual workers		Unskilled manual workers	
All cancers	1.00	1.08	1.05,1.10	1.29	1.24,1.34	1.25	1.20,1.31	1.27	1.24,1.30	1.40	1.35,1.44
Preventable cancers											
Head and neck	1.00	1.19	1.07,1.32	1.72	1.48,2.01	1.16	0.92,1.46	1.48	1.34,1.63	2.04	1.80,2.30
Oesophagus	1.00	1.00	0.90,1.12	1.06	0.87,1.28	0.89	0.70,1.13	1.13	1.02,1.26	1.25	1.08,1.44
Stomach	1.00	1.08	0.95,1.22	1.00	0.79,1.27	1.30	1.02,1.66	1.28	1.14,1.44	1.39	1.18,1.64
Colorectal	1.00	1.00	0.93,1.07	1.07	0.94,1.22	0.98	0.85,1.14	1.04	0.97,1.11	1.06	0.96,1.17
Liver	1.00	0.87	0.77,0.98	0.94	0.75,1.17	0.37	0.25,0.55	0.79	0.70,0.89	0.95	0.80,1.13
Lung	1.00	1.22	1.17,1.27	1.63	1.53,1.74	1.53	1.42,1.65	1.74	1.68,1.81	1.90	1.81,2.00
Prostate	1.00	0.95	0.87,1.05	1.08	0.91,1.28	1.35	1.16,1.57	0.94	0.85,1.03	1.07	0.94,1.23
Bladder	1.00	1.14	1.00,1.31	1.31	1.05,1.65	0.95	0.72,1.25	1.17	1.02,1.33	1.61	1.36,1.91
Malignant melanoma	1.00	0.89	0.74,1.08	1.27	0.95,1.69	1.23	0.86,1.75	0.74	0.61,0.89	0.74	0.56,0.99
Non-preventable cancers											
Pancreas	1.00	0.92	0.84,1.01	0.99	0.84,1.17	1.08	0.90,1.30	0.89	0.81,0.97	0.99	0.86,1.13
Kidney	1.00	1.05	0.93,1.19	1.05	0.84,1.32	1.09	0.85,1.39	0.97	0.86,1.10	0.90	0.74,1.09
Eye, nervous system	1.00	0.99	0.87,1.12	0.94	0.76,1.17	0.97	0.75,1.26	0.85	0.76,0.96	0.85	0.71,1.01
Non-Hodgkin	1.00	0.90	0.78,1.04	1.06	0.83,1.36	1.45	1.13,1.85	0.94	0.82,1.08	0.72	0.57,0.90
Multiple myeloma	1.00	1.07	0.89,1.28	0.79	0.54,1.15	1.75	1.30,2.35	0.92	0.76,1.10	0.99	0.76,1.30
Leukemia	1.00	1.00	0.87,1.15	1.16	0.92,1.47	1.50	1.20,1.88	0.99	0.87,1.13	1.06	0.87,1.28

WOMEN	Managers and professionals	Intermediate white-collar		Service and sales workers		Agricultural and fishery workers		Skilled manual workers		Unskilled manual workers	
Cancer deaths	1.00	1.01	0.97,1.04	1.03	0.98,1.07	1.26	1.14,1.38	1.05	0.99,1.11	1.17	1.12,1.22
Preventable cancers											
Oesophagus	1.00	1.13	0.86,1.50	1.58	1.14,2.19	1.15	0.52,2.51	0.94	0.56,1.60	1.40	1.00,1.97
Colorectal	1.00	1.11	0.99,1.25	1.06	0.91,1.23	0.88	0.61,1.26	1.37	1.15,1.64	1.11	0.95,1.28
Lung	1.00	1.14	1.04,1.25	1.31	1.18,1.47	0.90	0.66,1.22	1.35	1.17,1.55	1.66	1.49,1.84

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Breast	1.00	0.97	0.91,1.04	0.87	0.80,0.94	1.20	1.00,1.45	0.90	0.81,1.01	0.94	0.86,1.02
Cervix	1.00	1.00	0.77,1.29	1.41	1.05,1.89	0.71	0.26,1.94	0.89	0.58,1.37	1.72	1.28,2.30
Uterus	1.00	1.07	0.85,1.35	1.44	1.11,1.87	1.26	0.73,2.18	1.27	0.88,1.83	0.91	0.67,1.23
Bladder	1.00	0.78	0.52,1.15	1.25	0.81,1.93	1.26	0.50,3.15	1.13	0.63,2.04	1.11	0.71,1.73
Malignant melanoma	1.00	1.15	0.89,1.48	0.86	0.60,1.22	1.96	1.05,3.68	1.34	0.92,1.96	1.48	1.09,2.02
Non-preventable cancers											
Stomach	1.00	1.12	0.86,1.48	1.24	0.89,1.72	3.33	1.99,5.55	1.34	0.89,2.02	2.03	1.51,2.72
Liver	1.00	0.97	0.73,1.30	1.04	0.72,1.50	1.44	0.72,2.88	1.11	0.69,1.80	1.50	1.09,2.08
Pancreas	1.00	0.88	0.75,1.02	0.96	0.80,1.16	1.20	0.83,1.73	0.85	0.66,1.11	1.14	0.95,1.36
Ovary	1.00	0.88	0.77,1.00	0.92	0.78,1.08	1.91	1.45,2.50	1.01	0.82,1.25	1.07	0.92,1.26
Kidney	1.00	0.81	0.62,1.06	1.01	0.73,1.39	1.13	0.57,2.24	0.78	0.49,1.25	0.89	0.63,1.25
Eye, nervous system	1.00	0.79	0.66,0.95	0.92	0.73,1.15	1.13	0.68,1.88	0.84	0.62,1.13	1.06	0.85,1.32
Non-Hodgkin	1.00	1.18	0.91,1.53	1.12	0.80,1.55	1.38	0.72,2.64	1.61	1.10,2.37	1.21	0.87,1.67
Multiple myeloma	1.00	1.01	0.73,1.39	1.00	0.67,1.50	1.18	0.53,2.60	0.77	0.43,1.38	0.95	0.63,1.42
Leukemia	1.00	0.95	0.76,1.18	0.97	0.73,1.29	1.26	0.72,2.19	1.13	0.79,1.61	1.15	0.88,1.51

Reference category is managers and professionals
All analyses are adjusted for current age, region and migrant background

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	p. 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	p. 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	p. 3
Objectives	3	State specific objectives, including any prespecified hypotheses	p. 3
Methods			
Study design	4	Present key elements of study design early in the paper	p. 3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	p. 3
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	p. 3
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	p. 3
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	p. 3-4
Bias	9	Describe any efforts to address potential sources of bias	p. 5
Study size	10	Explain how the study size was arrived at	p. 3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	p. 3-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	p. 4-5
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	p. 4
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	p. 5
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	p. 5
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	p. 5
		(b) Indicate number of participants with missing data for each variable of interest	p. 5
		(c) Summarise follow-up time (eg, average and total amount)	p. 5
Outcome data	15*	Report numbers of outcome events or summary measures over time	p. 5
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	p. 5-10
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	p. 11-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	p. 11-12
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	p.10-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	p.10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	p. 13

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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